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Assessment of Progress of Selected Water Quality Projects of USDA and State Cooperators

Natural Resources Conservation Service
in cooperation with
the University of Vermont
and
Texas A&M University

July 1996

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ASSESSMENT OF PROGRESS IN SELECTED WATER QUALITY PROJECTS OF USDA AND STATE COOPERATORS
FINAL ASSESSMENT REPORT

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Abstract

This report analyzes the extent to which a case-study group of 16 water quality projects approved under the USDA Water Quality Program made progress toward improving and protecting water quality from agricultural nonpoint source pollution during FY 1991-1994. Progress toward this goal was assessed by three types of indicators: 1) producer adoption of conservation practices and agrichemical management improvements; 2) project staff competency in the use of models to simulate reductions in pollutant loadings to water; and 3) monitored water quality changes in impaired or threatened water bodies. The report focuses on indicator types one and three. Limited attention is paid to indicator type two in this report as modeling efforts were fully addressed in the 1993 Interim Report and findings and recommendations have not changed substantially. Over the four years of the assessment, the assessment team assisted each project in the use of new progress reporting software, simulation modeling, and water quality monitoring. Producers adopted a wide variety of both traditional and innovative practices and management changes that led reported average annual applications of nitrogen and phosphorus to fall by 54 lbs/acre and 32 lbs/acre, respectively. Improvements in pesticide management included shifts to chemicals of lower leaching potential, increased use of Integrated Pest Management practices, and some reductions in total quantities applied. Effective use of simulation modeling proved to be very challenging. Of the 16 projects, competency with field-scale and watershed-scale modeling was demonstrated in only six and three projects, respectively. Specific simulation results are available from individual projects. Water quality monitoring showed improvement at individual practices and instrumented sites but not at the project or watershed-level. This was due to the late start and limited resources for monitoring in many projects, absence of close coordination between practice/management adoption and monitoring activities, the time needed to implement many practices, and the five-year evaluation period relative to longer response times of natural systems. Several projects did establish baseline data sets and long-term monitoring designs that will be able to document future water quality changes due to project activities. The report presents recommendations for future water quality programs.

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Authorship and Acknowledgments

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<u>EXECUTIVE SUMMARY</u>

The principal objective of the USDA Water Quality Program was to provide farmers and ranchers with the assistance they need to respond independently and voluntarily to address environmental concerns and State water quality requirements. The Program required a program evaluation by the Education, Technical Assistance, and Financial Assistance (ET&FA) Committee of the USDA Working Group on Water Quality. This report is a major component of the ET&FA evaluation strategy for monitoring and evaluation of the water quality projects approved for operation under its auspices (McMullen et al, 1991). It analyzes the extent to which a case study group of 16 projects made progress during FY 1991-1994 toward improving and protecting water quality from agricultural nonpoint source pollution.

During 1990-1991, the ET&FA Committee oversaw the initiation of 90 Hydrologic Unit Area (HUA) and Demonstration Projects (DP), each designed to improve and/or protect water quality cost-effectively by reducing agricultural nonpoint source pollution. Primary contaminants included nitrate and phosphorus from inorganic and organic sources, sediment, and pesticides. Reduced pollution was to be achieved through voluntary adoption of a) improved nutrient and pesticide management in crop and livestock enterprises, b) erosion and sediment control practices, and c) improved irrigation water management.

HUA projects focused on remediation of documented water quality problems in watersheds by providing educational, technical, and financial assistance to support widespread implementation of USDA-tested practices to protect water quality. DPs were located in broad areas of actual or potential water quality impairment, not necessarily in whole watersheds, and demonstrated innovative practices at specific sites, combined with education efforts to accelerate wider adoption of new practices by producers.

A case-study group of 8 DPs and 8 HUAs encompassing a wide range of geographic setting, agriculture type, and water quality problem was used to document the extent to which the projects made progress toward improving or protecting water quality. Progress was evaluated through three types of indicators:

- Producer adoption of conservation practices and agricultural management changes
- Project staff competency in use of models to simulate reductions in sediment, nutrient, and pesticide losses from the edge-of-field or bottom-of-root zone
- Monitored changes in water quality in impaired or threatened water bodies

Indicator Type I: Adoption of Practices and Changes in Agrichemical Management

There was substantial adoption of conservation practices and improved management among the case-study projects, including 66 different practices with national standards and specifications and another 68 practices, including some with State-approved components of nationally defined practices as well as new or innovative practices that were demonstrated in the DPs. The most widely adopted national practices included nutrient management, irrigation water management, conservation cropping, cover/green manure crop, conservation tillage, pesticide management, and animal waste utilization.

Most of the projects initially lacked formal, detailed land treatment tracking or agricultural management monitoring. However, by FY 1994 all were doing an adequate job of tracking basic land treatment and several undertook more intensive efforts to track actual management changes, including use of a Geographic Information System (GIS) to spatially reference these changes.

The projects reported substantial improvements in agrichemical management. Estimated reductions in annual nitrogen application rates averaged across participating acreage in each project ranged from 14 to 129 pounds/acre; estimated reductions in phosphorus ranged from 3 to 106 pounds/acre. Total annual reductions as of FY 1994 were a reported 22.3 million pounds of nitrogen and 10.3 million pounds of phosphorus. Assessment of overall change in pesticide applications was much more complex because changes involved timing, formulation, and method, not only rates of application. However, several projects reported significant improvements in pest management and more effective targeting of pesticide management practices to problem soils.

Indicator Type II: Simulated Reductions in Pollutant Loadings

Project staff in several projects raised capabilities to use very complex physical process simulation models to project changes in pollutant losses from agricultural land due to changes in conservation practices and agrichemical management. While few individuals among project staffs had experience with models at project initiation, six project annual reports showed that staff had acquired a high degree of competence in field-scale model calibration, clear documentation of modeled results, and proper and logical discussion of results in terms of the water quality objectives of their project. Field-scale model use in the remaining ten project reports was poorly documented or not reported. The field-scale model used most frequently was EPIC. Only three projects demonstrated clear skill in using watershed-scale models; AGNPS was the most widely used watershed-scale model. In summary, effective use of simulation modeling proved to be very challenging. Broad water quality implications suggested by the Assessment team's study of the unique results found in several individual project reports were not considered useful for this report. Specific results are available from each project.

Indicator Type III: Monitored Water Quality Changes
Water quality monitoring was not designed specifically into any of the projects, but most projects did engage in some form of monitoring, generally added after project inception. Four of the projects were able to provide solid evidence of project impact on improving water quality through monitoring. However, most of these five-year projects were unable to document impacts through monitoring due to inadequate monitoring design and/or resources, lack of control for spatial and temporal variability, long hydrologic lag time, or other limitations. Direct assessment of project-level impacts through water quality monitoring during the projects' lifetime was probably not feasible given the late start on monitoring in many projects, the absence of close coordination between implementation of treatment and the design of monitoring, the time needed to implement many practices, and the response time of natural systems. While many progress reports claimed significant impacts on water quality for the projects, such statements were rarely supported by solid monitoring data. The most obvious cause of this was the short project period; many projects correctly stated that five years was too short a time to demonstrate water quality improvements. Major difficulties also stemmed from the failure to give water quality monitoring and evaluation adequate priority at the program level when project plans were formulated. As a consequence, many of the monitoring activities that were undertaken or adapted from external ongoing programs had goals and capabilities poorly suited to project operation and evaluation. Monitoring was not well integrated into total project management and operation.

Many projects were successful in using water quality monitoring to: 1) document the effectiveness of specific management practices or of demonstration sites in improving water quality; 2) establish a baseline water quality data set potentially useful in documenting <u>future</u> changes in water quality; or 3) initiating well-designed long-term monitoring efforts that can detect response to treatment.

Recommendations
PROGRAM AND PROJECT PLANNING

- Selection criteria for land treatment/water quality projects should include probability of project cooperation with strong existing state or federal nonpoint source monitoring and evaluation programs.

- Future land treatment/water quality projects should be located in hydrologically favorable areas and in areas where the relationship between pollutant source areas and impaired water bodies is known. Areas with extremely long ground water travel times, where the project area contributes only a small proportion of the water or pollutant load or where pollutant movement pathways are poorly understood, for example, should be avoided because the probability of successful documentation of water quality response to land treatment is very small.

- A systematic, objective, and credible means of targeting treatment to critical problem areas is needed in all water quality projects. Identification and prioritization of pollutant source areas, based on local staff knowledge, quantitative pollutant loss screening tools, physical process simulation models, and land management and water quality data should be initiated in the early stages of project planning.

- To be used effectively in evaluation of land treatment project impacts, water quality monitoring must focus specifically on the project area and be designed into the project from the start. Integration of monitoring into the project mainstream can foster important feedback loops between land treatment and monitoring efforts that can improve targeting of land treatment, as well as overall project management and operation.

- Future land treatment/water quality programs should provide guidance on the use of specific performance measures to evaluate project performance.

- Land treatment/water quality projects should establish quantitative goals for adoption of land treatment measures and improvements in agrichemical management, based on best available estimates of changes required to protect or improve water quality.

- USDA efforts to establish a conservation practice and management improvement tracking and accounting system that staff in all projects would use to record the amounts, landscape locations, physical and financial effects of practice adoption, technical and financial assistance from project sponsors, and other characteristics of all producer actions that can affect subsequent water quality conditions needs to continue receiving high priority. The ADSWQ software developed for this assessment and the NRCS Field Office Computing System (FOCS) now being developed should be considered in this regard. Project staff should be trained in the capabilities and use of the system during project planning.

- USDA agencies should design and implement non-intrusive procedures to track: a) practice adoption and agrichemical management improvements by producers within a water quality project area but who do not directly receive technical, financial, or educational assistance; and b) general watershed trends in land and water management.

- USDA agencies should develop and implement a system capable of assessing the level of operation and maintenance of implemented structural and adopted nonstructural conservation practices in a project area after that project has been terminated. Anticipated water quality benefits will not occur if producers do not continue to apply annual project-promoted practices, for example, nutrient or pesticide management, or if local sponsors do not maintain structural measures.

STAFF TRAINING

- USDA agencies should continue to place high priority on the development of and training in the use of analytical screening tools for nutrient and pesticide leaching and runoff and sediment production to assist in identifying potential pollutant source areas and areas to target management improvements.

- USDA agencies should continue to emphasize development of staff capabilities to choose appropriate simulation models, both field-scale and watershed-scale, acquire reliable input data at least cost, and use selected models properly, including output interpretation and sensitivity analysis. Given the significant time required for an individual to become able to quickly and effectively use models in project planning and in simulation of future water quality effects, agencies should focus training on a cadre of individuals who could assist multiple projects.

- USDA agencies and their cooperators should continue to train water quality program leaders in key concepts of water quality monitoring in order to promote close coordination and interaction with water quality monitoring capabilities of other federal and state partners.

PROJECT ASSESSMENT

- Assessment of project impacts on water quality through monitoring should be an important component of future USDA-sponsored land treatment/water quality programs. Clear documentation of water quality response to soil and water conservation practices and improved management practices at the <u>project</u> level should be a major goal. However, full documentation is not needed on every project. A few carefully designed projects should be selected for full project evaluation effort, in partnership with water quality monitoring agencies, both state and federal.

- In projects not selected for full evaluations, necessary evaluation should be based on land treatment tracking, documented changes in agrichemical application and management, and model projections as secondary indicators of impact.

- Even simple, inexpensive water quality monitoring should be considered in project design for impact assessment. Rudimentary monitoring comparing water quality upstream and downstream of a practice, for example, can: 1) suggest the effectiveness of installed practices on in-stream water quality; 2) document those water quality variables which may respond to the treatment program and should therefore be monitored at a watershed outlet to document overall program effects; and 3) provide evidence useful in enhancing producer and public acceptance of improved management. Involving project staff directly in monitoring and evaluation can establish vital cooperation, information sharing, and feedback between land treatment and water quality activities.

- Monitoring of water quality at the practice or site may be necessary to document practice effectiveness, to predict which water quality variables are likely to respond to the land treatment program, or to promote producer adoption. Such monitoring should, however, be considered only an indirect measure of overall project impact because changes resulting from the adoption of individual practices may not result in watershed-level response.

- The evaluation period for water quality response to land treatment at watershed scales should be longer than the five-year duration of the projects in this Assessment and ideally should be tied to the response time of the natural system.

- Opportunities to integrate water quality monitoring and simulation models for project planning and evaluation should continue to be explored. Modeling can project changes that are difficult, costly, or time-consuming to monitor. During project operation as well as during planning, appropriate modeling permits comparative estimation of pollutant loadings under different project scenarios. Monitoring can provide data essential for model validation and can address water quality dimensions not handled by currently available models.

- While producer adoption of soil and water conservation practices and initial management changes may be accomplished relatively rapidly, some provision for continued assessment of long-term management changes and project impacts on water quality should be considered, especially when a sophisticated monitoring and evaluation program is initiated. When assessment results are expected long after the completion of the land treatment program, a mechanism for tracking projects and incorporating understanding of their ultimate impacts into agency program knowledge must be developed.

1.0 INTRODUCTION

The United States Department of Agriculture (USDA) Water Quality Program was implemented in FY 1990 in response to national concern over the declining quality of ground and surface waters. The principal objective of the Program was to provide farmers and ranchers with the assistance they need to respond independently and voluntarily to address environmental concerns and help meet State water quality requirements. The Program requires a program evaluation by the Education, Technical Assistance, and Financial Assistance (ET&FA) Committee for the USDA Working Group on Water Quality[1].

This report is a major component of the ET&FA evaluation strategy for monitoring and evaluation of the water quality projects approved for operation under its auspices (McMullen et al, 1991)[2]. It analyzes the extent to which a case study group of 16 projects, each sponsored by the USDA and State and local cooperators, made progress during FY 1991-1994 toward improving and protecting water quality from agricultural nonpoint source pollution. Performance was assessed by means of three types of indicators:

1. Producer adoption of conservation practices and agrichemical management improvements

2. Use of models to simulate reductions in loadings of potential pollutants to water

3. Monitored water quality changes

This report focuses primarily on indicator types 1 and 3. Issues with type 2 were treated in the 1993 Interim Report (Sutton et al., 1993).

The project team (J. D. Sutton, USDA-NRCS; D.W. Meals, University of Vermont; and R. H. Griggs, Texas A&M University) conducted the Assessment from 1991-1995 through site visits with project staff in 1991-1992, analysis of project annual reports, a computerized land treatment data base, and a variety of workshops and meetings (Sutton, et al., 1992 and 1993). This report is an update of an interim assessment conducted in 1992-1993. It considerably expands discussion of the use of and results of water quality monitoring in the case-study projects.

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[1] Three USDA agencies are ET&FA co-chairs. They are the Natural Resources Conservation Service (formerly SCS), the Cooperative State Research, Education, and Extension Service (formerly ES), and Farm Services Agency (formerly ASCS).

[2] Other components complete the ET&FA evaluation. They are: 1) Assessment of the Organization and Initial Implementation of the Demonstration Projects Approved in 1990); 2) Evaluation of Producer Adoption in the Demonstration Projects to be published in late 1996 (see Nowak and O'Keefe, 1992); and 3) economic analysis of four projects by the Economic Research Service. An overall evaluation of the principal objectives of the Water Quality Initiative would be based upon all components of the ET&FA evaluation strategy.

2.0 PROJECTS SELECTED FOR THE ASSESSMENT

This report is based on the data and analyses developed by a case-study group of eight Demonstration Projects (DPs) and eight Hydrologic Unit Area projects (HUAs):

Demonstration Projects
- Anoka Sand Plain, Minnesota
- Herrings Marsh Run, North Carolina
- Lake Manatee Watershed, Florida
- Mid-Nebraska, Nebraska
- Monocacy River Watershed, Maryland
- Sacramento River Rice Herbicide, California
- Seco Creek, Texas
- Water Quality Demonstration Project-East River, Wisconsin

Hydrologic Unit Areas
- East Sidney Lake, New York
- Illinois River Sands, Illinois
- Inland Bays, Delaware
- Little Bear River, Utah
- Ontario, Oregon
- Sand Mountain/Lake Guntersville, Alabama
- Sycamore Creek, Michigan
- Upper Tippecanoe River, Indiana

The locations of these projects are shown on Figure 2.1. The 16 projects included many of the major agricultural nonpoint source problems occurring in the population of 90 projects (16 DPs and 74 HUAs) authorized for operation by ET&FA agencies in FY 1990 and 1991.

2.1 Project Characteristics

The 16 projects were selected as a case-study group and were not intended to be a strictly representative sample of the population of land treatment-water quality projects. However, the projects selected encompassed a wide range of geographic setting, agriculture type, and water quality problem characteristic of agricultural nonpoint source pollution in the United States. Table 2.1 summarizes the main characteristics of the projects; brief project descriptions are presented in Appendix A.

The projects fell into two main groups defined by impaired water body, agriculture type, and nonpoint source pollutant:

Group I included eight projects primarily concerned with surface waters impaired by sediment, nutrients, animal wastes, bacteria, and riparian degradation generated by livestock production and/or by non-irrigated cropland DPs in Maryland, North Carolina, and Wisconsin and HUAs in Alabama, Indiana, Michigan, New York, and Utah were in this group. Eutrophication, sedimentation, oxygen demand, and habitat degradation have impaired streams and lakes for fisheries, drinking water, recreation, and aesthetics. Common agricultural management problems included inadequate cropland and streambank erosion control, sediment from cropland, excessive fertilizer application, and inadequate animal waste management. The dominant project goals were to reduce nutrient and sediment loads to receiving waters and/or reduce pollutant concentrations in receiving waters.

The six **Group II** projects addressed contamination of shallow ground water and associated surface waters with nitrate and pesticides leaching from irrigated cropland. DPs in Florida, Minnesota, and Nebraska and HUAs in Delaware, Illinois, and Oregon were in this group. Nitrate concentrations exceeding the EPA Maximum Contaminant Level (MCL) in drinking water, excessive nitrogen loading to surface waters, and occurrence of corn herbicides and other pesticides in drinking water were typical of the water quality impairments in this group of projects. Common agricultural management problems included excessive nitrogen application rates, inadequate management on sandy soils, poor irrigation water management, and excessive pesticide application rates. Two projects focused on threatened rather than currently impaired aquifers. The main goals of Group II projects were to reduce nitrate and pesticide loads leaving the bottom of the root zone and/or reducing actual pollutant levels in ground water.

Two DPs did not fit into the two larger groups. The Texas DP focused on a closely interconnected surface water/ground water system. The major issues related to sediment movement from rangeland and nutrient and pesticide movement from cropland, pastureland, and rangeland into the Edwards aquifer, the principal water source for San Antonio.

The California DP was directed toward reducing release of pesticide residues from irrigated rice production to the Sacramento River system. Irrigation tailwater management was the primary agricultural management issue in this project.

Figure 2.1

LOCATIONS OF CASE-STUDY PROJECTS

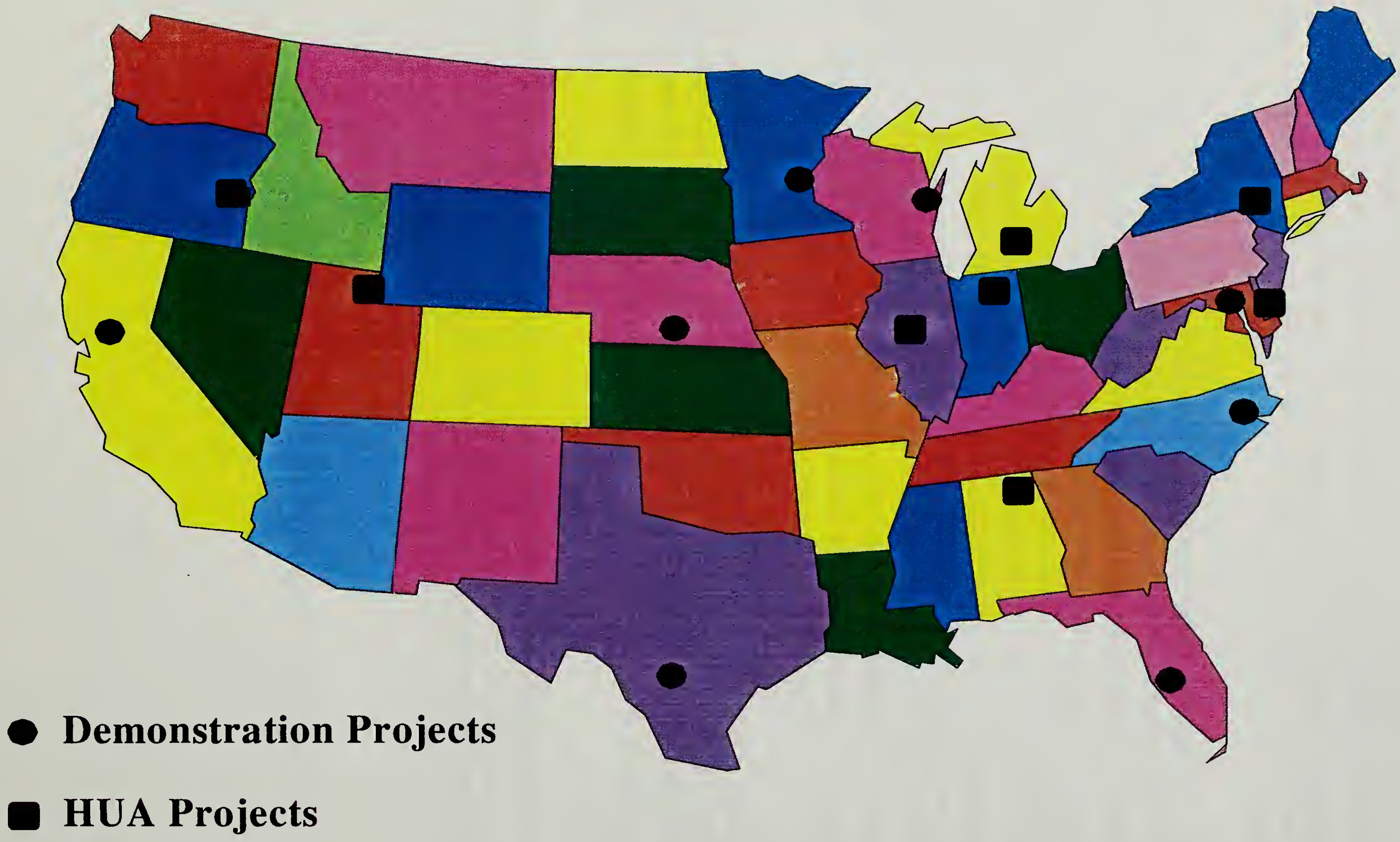

Table 2.1. Characteristics of sixteen Assessment projects.

	----------Demonstration Projects----------								------Hydrologic Unit Area Projects-----								
	MD	WI	FL	NC	MN	NE	TX	CA	NY	DE	AL	MI	IN	IL	UT	OR	Total
Surface Water	x	x	x	x			x	x	x	x	x	x	x		x	x	13
River/Stream	x	x		x			x	x				x			x	x	8
Lake/reservoir	x	x	x						x		x		x		x		7
Estuary										x							1
Groundwater	(x)	(x)	x	x	x	x	x			x		(x)	x	x		x	12
Deep	x	(x)				x	x					(x)					5
Shallow	(x)	(x)	x	x	x					x			x	x		x	9
Irrigated cropland		x	x		x	x	x	x					x	x		x	9
Dairy/Beef	x	x	(x)		x				x			x	x		x	x	9
Poultry/Hogs	x				(x)					x	x	x	x				6
Nitrate	x	x	x	x	x	x	x			x	x	x	x	x		x	13
Phosphates	x	x	x	x			x		x		x	x	x		x		10
Sediment	x	x		x			x		x		x	x	x		x	x	10
Pesticides	x	x	(x)	x	x	x	x	x				x	x	x		x	12
Animal Waste	x	x		x	x		x		x	x	x	x	x		x	x	12

Note: (x) signifies a secondary characteristic

Several key differences between the DP and HUA projects are relevant to this Assessment:

- HUAs were located only in discrete watersheds that States identified under Section 319 of the Clean Water Act as having significant water quality impairment from agricultural nonpoint sources. DPs were located in areas of actual or potential water quality impairment; these areas were often not distinct watersheds but groupings of adjacent administrative units.

  Because HUAs tended to focus on remediation of documented water quality problems in distinct drainages, their effectiveness might be measured by improvements in water quality at a watershed outlet. Since DPs operated in broad areas or addressed prevention of pollution, measurement of physical impacts was more difficult.

- HUAs provided technical assistance for widespread implementation of USDA-tested conservation practices and systems of practices. In contrast, DPs focused on demonstration of relatively new practices at a limited number of sites with intensive technical assistance (demonstration sites), combined with education efforts to accelerate widespread adoption of new practices by producers.

  As a result, HUAs were generally designed with specific goals for practice implementation based on some assessment of land treatment needs, while DPs tended to be more focused on information and education.

2.2 Project Approaches to Impact Assessment

Approaches to assessing project impacts generally included some combination of agency land treatment implementation records, producer or agency agrichemical use records, physical process model simulations, and water quality monitoring. Guidance from ET&FA agency staff with regard to measurement of physical impacts was not provided to project staffs until August, 1991, well after projects were planned, funded, and underway. The specific mix of activities undertaken by the projects to evaluate their impact were as varied as the projects themselves.

All projects tracked practice adoption and agricultural management to some degree, but methods varied. Approaches to verification that producers were applying nutrients and pesticides more effectively included: a) collection of detailed application and management data from producers; b) discussion with producers about their changes in management relative to their conservation plan; and 3) in a few cases for nutrient management, assuming that the specifications of the conservation plan were being met. New data base management software for tracking practice implementation was developed by the Blackland Research Center of Texas A&M University with USDA for use in the Assessment projects ("Automated Data System for Water Quality," or ADSWQ). Staff in many of the projects used simulation models to estimate changes in runoff and leaching of chemicals due to application of improved management and/or conservation practices.

Most projects engaged in some form of water quality monitoring funded and carried out by a non-ET&FA agency. This monitoring included site-level monitoring of specific practices, ambient monitoring of project area waterbodies, regional monitoring projects, and a few intensive monitoring studies specifically designed to evaluate the particular project.

3.0 PROGRESS, FY 1991 THROUGH FY 1994

This section reports on reported changes in agrichemical use and management, use of models to simulate reductions in leaching and runoff of chemicals, and measured changes in water quality.

3.1 Improvement in Land and Water Management

Improvements in agrichemical management were evaluated by project success in bringing about adoption of conservation practices, targeting of practices to problem areas, tracking land treatment, and assessing reported improvements in agrichemical use.

3.1.1 Adoption of conservation practices[3] There was substantial implementation of conservation practices among the case-study projects. Some 134 different practices were installed; 66 of these were those with national standards and specifications. Another 68 practices included State-approved components of nationally defined practices and new or innovative practices that were demonstrated in the DPs. The most prevalent national practices adopted are shown in Table 3.1.

Implementation data for all conservation practices are shown in Appendix B. The data reported through the ADSWQ program are likely to be underestimates because permanent practices may have been recorded only in their first year when most USDA assistance was provided even though producers would reapply the practice in subsequent years. Reinstallation by producers was only tracked for practices requiring multi-year assistance from USDA, not for permanent practices which required assistance only in the year of installation. Terracing is an example of such an permanent practice. Furthermore, adoption of practices without technical assistance provided by project staff could not be readily tracked in either HUAs or DPs. Finally, a number of projects had difficulty using the ADSWQ software (see Section 3.1.3) and believe that actual implementation has been under-reported. Evaluation staff could not confirm this belief.

Conservation practices were adopted in significant quantities. Nutrient management practices were implemented in 15 of the 16 projects. Twelve projects installed erosion control measures and eight applied pest management practices.

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[3] Practices include both those conservation practices having national standards and specifications established and approved by NRCS as well as new and innovative practices being tested and demonstrated by other project sponsors.

Many innovative practices highly specific to local agriculture were demonstrated. The Florida DP, for example, promoted more efficient irrigation water management systems developed for vegetable production under plastic mulch on sandy soils. The Oregon HUA used straw mulch and field borders in furrow-irrigated fields to reduce erosion and sedimentation. The California DP demonstrated two innovative irrigation tail-water management systems designed to reduce release of pesticide residues from rice production.

Table 3.1. Predominant national practices reported adopted in Assessment projects.

Practice Name	Amounts	Units	No. of Projects
Waste Storage Structure	340	#	7
Conservation Cropping Sequence	131,635	acre	12
Conservation Tillage	114,695	acre	7
Cover/Green Manure Crop	121,026	acre	8
Crop Residue Use	52,486	acre	7
Fencing	188,540	feet	3
Irrigation Water Conveyance	788,209	feet	4
Irrigation Water Management	334,389	acre	7
Proper Grazing Use	130,545	acre	3
Nutrient Management	451,521	acre	15
Pesticide Management	99,655	acre	8
Animal Waste Utilization	75,111	acre	10

Source: Project annual progress reports and ADSWQ tables.

HUA projects generally set goals for practice implementation; these goals are compared to actual implementation through FY 1994 for practices having national standards in Table 3.2. For about half of the practices, implementation exceeded goals. This was particularly true for conservation cropping and waste utilization. Implementation of a few practices such as grassed waterway and stripcropping fell significantly short of project goals.

The reasons for slow rates of adoption for some practices were not always thoroughly discussed in project reports. However, reasons frequently cited, without analysis, included general lack of producer interest; the depressed farm economy; producers lack of understanding about continued overuse of fertilizers and pesticides due to unrealistic yield goals, economic thresholds, or real risks; contractual arrangements with buyers that removed some decision capacity from producers; shortages or limitations on federal cost-share funds; shortage of local contractors to install practices; permit procedures; and producer preferences for locally accepted practices over practices with national standards and specifications.

It should be noted that improved understanding of agricultural management issues and needs for water quality protection often developed with experience and may have shifted priorities from initial practice goals.

Quantitative practice implementation goals were less relevant to DPs than to HUAs because the objective of DPs was to accelerate voluntary adoption of innovative practices. The process of practice adoption in the DPs is being evaluated in a separate study to be published in late 1996 (see Nowak and O'Keefe, 1992), which hypothesizes that practice adoption is not simply an adopt/not-adopt process, but may progress through stages from awareness and interest, through evaluation and trial, to full acceptance of new technology. A significant time lag in adoption may occur as the acceptance process overcomes issues like fear of crop losses or yield decreases.

DPs were generally not set up to effectively track adoption of demonstrated practices, especially if adoption occurred without assistance from project sponsors. Therefore, it is very difficult to document adoption in DPs beyond the designated demonstration sites. Where this has been done, however, results can be impressive. Table 3.3 shows practice adoption from two DPs that were effective in documenting adoption on both demonstration sites (i.e., farm or ranch fields where project staff, with the cooperation of the land owner, demonstrated project practices.) and non-demonstration sites (elsewhere within the DP where operators adopted practices without project on-farm demonstration assistance). In these two cases, implementation of innovative management practices beyond the limited demonstration sites was clearly significant.

3.1.2 Targeting problem areas. For land treatment practices to achieve water quality goals cost-effectively, their installation should be targeted to the critical problem areas. Assessment team interviews and on-site observations indicated that project staff have a strong appreciation for the need to target. However, targeting is not an easy or straightforward process in voluntary programs, nor do effective and universally applicable procedures for targeting exist.

Table 3.2. Land treatment and agricultural management practices reported adopted vs. goals, FY 1991-1994, for eight Hydrologic Unit Area projects.

Practice[1]	Goal	Installed	Percent of Goal
Cover/green manure	105,000 acre	26,334 acre	25%
Nutrient management	192,200 acre	125,123 acre	65%
Conservation tillage	50,000 acre	99,995 acre	200%
Pasture/hayland planting	1,200 acre	3,676 acre	306%
Pest management	87,400 acre	16,010 acre	18%
Waste storage system	38	76	200%
Waste storage structure	64	137	214%
Waste treatment lagoon	43	25	58%
Waste utilization	1,000 acre	14,703 acre	14,700%
Conservation cropping	2,100 acre	99,321 acre	47,296%
Critical area planting	10 acre	58 acre	580%
Diversion	5,800 feet	2630 feet	45%
Grassed waterway	10,700 acre	33 acre	<1%
Stripcropping	1,500 acre	160 acre	11%
Water/sediment control structure	255	89	43%

[1] Because HUA projects normally assisted in producer adoption of established conservation practices, project staff were able to more easily set adoption goals than were DP staff. The focus of the latter type of project was to demonstrate new and innovative practices in the project area for subsequent testing and adoption by producers.

Source: Project annual progress reports and ADSWQ tables.

Table 3.3. Reported adoption of practices on demonstration sites and non-demonstration areas in the Lake Manatee, FL and the Mid-Nebraska Demonstration Projects. Figures represent total adoption as of end of FY 1994.

	Practice Name[1]	Unit	Demo Site[2]	Non-Demo	Total
FL	Irrigation water convey (430DD)	feet	0	2000	2000
FL	Trickle irrigation system (441A)	acre	350	15282	15632
FL	Surface/subs. irr. system (443A)	acre	195	400	595
FL	Cover Cropping	acre	504	141100	141604
FL	Tissue analysis	acre	470	23500	23970
FL	Split application of nitrogen	acre	1035	52400	53435
FL	Alternative nitrogen formulation	acre	20	2400	2420
FL	Double cropping	acre	544	51700	52244
FL	Scouting	acre	0	48450	48450
FL	Pesticide selection	acre	0	200	200
FL	Water table monitoring floats	acre	1138	16975	18113
FL	Fully enclosed seeps	acre	316	6114	6430
FL	Brush management (314)	acre	0	644	644
FL	Cover/green manure crop (340)	acre	729	86462	87191
FL	Crop residue use (344)	acre	0	482	482
FL	Irrigation water management (449)	acre	0	8286	8286
FL	Pasture/hayland management (510)	acre	0	810	810
FL	Proper grazing use (528)	acre	0	1073	1073
FL	Planned grazing system (556)	acre	0	4246	4246
FL	Row arrangement (557)	acre	0	482	482
FL	Nutrient management (590)	acre	521	4996	5517
FL	Pest management (595)	acre	521	9873	10394
NE	Irrigation water conveyance (430DD)	feet	0	74752	74752
NE	Irrigation water conveyance (430EE)	feet	0	399305	399305
NE	Sprinkler irrigation system (442A)	ace	1848	5115	6963
NE	Surface/subs. irr. system (443A)	acre	2165	0	2165
NE	Surge irrigation	acre	1075	2160	3235
NE	Conservation crop. sequence (328)	acre	0	705	705
NE	Tailwater recovery (447)	#	9	229	238
NE	Irrigation water management (449)	acre	5873	151467	157340
NE	Nutrient management (590)	acre	0	44144	44144
NE	Pest management (595)	acre	5782	44896	50678

[1] Practice names are reported. They are a mix of new practices tested by the projects and of practices established and nationally approved by NRCS. For clarity,those with national standards are listed with their numerical code.

[2] Demo sites were locations where project staff with the cooperation of the land owner installed and demonstrated the effectiveness of project practices. Non-demo areas were locations elsewhere with the DP area where operators adopted practices without project on-farm demonstration assistance.

Source: FL and NE DP FY1994 annual progress reports, and ADSWQ tables.

Targeting is made even more difficult when multiple, sometimes conflicting, resource problems must be considered, problems such as pesticide leaching, surface runoff of nutrients, protection of endangered species, sufficient water supply for reliable irrigation scheduling, and maintenance of farm income, to name but a few. Targeting is still more difficult in DPs when practice adoption depends entirely on voluntary acceptance of new and innovative practices for which project sponsors and local producers have limited knowledge.

Different degrees of targeting have occurred among the Assessment projects. Perhaps the most widely applied method was reliance on local staff knowledge concerning the nature and location of problem activities and soil erosion. While this approach may seem at times to be very informal and qualitative, the application of such specific local knowledge can be crucial for focusing information and education activities, both formal and informal, and for project guidance. In some projects, field staff went a bit further by systematically identifying known problems or sources, e.g. field gullies, streambank erosion, or direct runoff from livestock operations.

In the Alabama HUA, for example, project staff approached targeting through a combination of TVA aerial inventories of potential nonpoint source contributing areas, plus project staff use of FSA records. In general, animal waste sites in this project were given priority over cropland erosion sites, and were themselves ranked in priority by project staff. In the Florida DP, site monitoring revealed that citrus groves should be targeted to reduce nitrate leaching.

Targeting was approached and documented most systematically in about one-half of the projects with respect to soil/pesticide interactions. Table 3.4 shows a partial tabulation of the implementation of pest control measures by soil leaching potential for pesticides. It should be noted that this table is based on incomplete data reported by seven of the eight Assessment projects that implemented pest management practices. Implementation of most of the pest control practices where pesticide leaching is a direct and immediate concern, e.g. pesticide selection, pesticide application/timing, IPM plans, implementation has occurred predominantly on soils of severe leaching potential. This performance suggests some success in targeting treatment to likely problem areas. Project staff were able to identify these areas using the Soil Pesticide Interaction Screening Procedure (SPISP).

Documented use of systematic targeting of nutrient management and/or erosion control was not as evident as it was for pesticides in the Assessment projects. Very little information was reported systematically, for example, on implementation of nutrient management practices with respect to leaching or runoff potential or other potential targeting measures such as soil nutrient levels determined by soil test. Technically acceptable nutrient leaching/runoff screening procedures are not widely available.

Table 3.4. Reported adoption of pest control measures in seven case-study projects.

Practice	Soil Leaching Potential for Pesticides Severe	Moderate	Slight
	----------- % of all implementation-----------		
Pest Management[1]	9%	89%	2%
Brush Management	<1%	2%	98%
Prescribed Burning	0	9%	91%
Pest Scouting	71%	14%	15%
Pesticide Selection	87%	12%	1%
Pesticide Application Timing	74%	8%	18%
Mechanical Control	89%	10%	1%
Crop Rotations	72%	10%	18%
IPM Plans	87%	10%	3%

[1]NRCS Practice 595. Other practices listed may be components of this national practice.

Source: Project annual progress reports and ADSWQ tables.

3.1.3 Documenting nonpoint source management through land treatment tracking. Detailed tracking of land treatment implementation is essential to document improvements in agrichemical management. We include in our definition of progress the process of setting up a methodology or procedure to track the implementation of changes in management that might affect water quality. At the start of the projects, there were no systematic requirements or guidance for establishing baseline conditions or for tracking practice implementation and agricultural management beyond normal cost-accounting or staff activity reporting, e.g. number of contracts signed or number of plans adopted. Consequently, there was initially not a high level of commitment among many of the projects to engage in deliberate, detailed tracking of ongoing agricultural management activities or the use of improved management practices, e.g. quantities of nitrogen or phosphorus actually applied. Initially, the Assessment projects showed a wide variety of quality and intensity of tracking efforts.

At the behest of the Assessment Team, about half the projects estimated baseline conditions with respect to cropping practices and management, as well as land treatment needs within one year after the projects were approved for operation. Many projects recorded and reported contracts signed, acres treated, and other very basic implementation information. By FY 1994, ten of the projects had adopted procedures to record detailed management improvements, including nutrient and pesticide application methods and rates. By FY 1994, all the Assessment projects were doing an adequate job of tracking basic land treatment information such as extent of practice implementation and changes in agrichemical application rates.

In general, project staff developed an appreciation for the need for collecting agricultural management data in some detail, including the need for knowing actual management, not only plan guidelines. This represents significant progress in project operation.

In 1992, most of the projects began to use new progress tracking software - "Automated Data System for Water Quality" (ADSWQ) (USDA-NRCS, 1994). This menu-driven data entry system was designed to aid project staff to electronically record practices adopted and to compile the potential and/or measured effects of these treatments on a farm field-by-field basis. The software also allows for aggregation of data from multiple projects for program reporting. While ADSWQ proved difficult for some projects to use effectively, it provided a consistent framework for project reporting. A few projects continued to use NRCS' Computer Assisted Management Planning System (CAMPS). Others recorded adoption in model input files needed for their use of simulation models.

Sources of data for tracking practice implementation and changes in agricultural management varied. Many projects relied on management plans signed by producers and on cropping activities reported to project sponsors, which in some cases was limited to information on activities which received cost-share, educational, or technical assistance. Several projects conducted farmer interviews or surveys to obtain information on application and use of conservation practices.

Most land treatment tracking tended to focus mainly on arithmetic reporting of implementation and largely ignored spatial aspects, i.e. where the treatments were applied on the landscape. Consideration of the location of land treatment is often crucial to meeting water quality goals. Some rather sophisticated tracking was adopted in some projects.

> The Michigan HUA tracked land treatment and land use at the subwatershed level by linking land treatment data from ADSWQ with other spatially defined attributes in the GRASS GIS. This approach allowed tracking of not only what conservation practices were implemented but also where in the watershed, e.g. how far from surface water.
>
> The North Carolina DP developed a method to track land treatment and land use at the subwatershed level to link water quality monitoring results with project land treatment implementation. Staff compiled all cropland information in a relational data base and digitized cropland fields, hydrography, and other baseline information into a GIS.
>
> In the Oregon HUA, an approach linking the U.S. Environmental Protection Agency's River Reach data base with GRASS was developed to allow spatial tabulation of conservation practices in a hydrologically meaningful way. This system has since been applied to another (non-Assessment) HUA.

In the Texas DP, a link between GRASS and the SWAT model was adopted that both tracks changes in land use and relates these changes to simulated water quality changes.

Approaches to land treatment tracking that convey information on the spatial distribution of conservation practices within a watershed are potentially very valuable in evaluating relationships between land treatment programs and water quality response.

Some concerns remain about land treatment and management tracking.

- Some practices, such as ICM and IPM, and practices contracted under LTAs, require annual certification by producers that they are maintaining the practices as installed. Except for practices where multi-year funding and technical assistance are needed from USDA, project staff have no formalized procedures to determine if producers are actively following conservation plans in years following initial assistance. Failure of a producer to follow the specifications of a nutrient management practice in subsequent years would, of course, affect the accuracy of the reported results.

- Land treatment and management tracking is far more difficult in a DP than in an HUA project, because producers may adopt a demonstrated practice without seeking technical or cost-share assistance. Because of the innovative nature of the practices, national standards often do not exist and cost-sharing funds are limited. A better system is needed to track the actual extent of treatment in such cases.

- Data confidentiality was a sensitive issue in some projects. Producers and/or agribusiness were sometimes reluctant to provide information on agrichemical applications, especially pesticide applications.

- The tracking system should allow the user to record practices and management changes, their spatial location relative to water, their estimated effect at the field and watershed level, the source of the effect estimate (e.g. survey, simulation, water quality monitoring), and the private and public costs of the practices.

Such obstacles need to be overcome in order to effectively assess project success.

3.1.4 Reported improvements in agrichemical use. Reported annual reductions in nitrogen and phosphorus use are summarized in Table 3.5, reporting quantities of nutrients not applied in project areas due to improved management. Average annual reductions in nitrogen applications ranged from 14 pounds/acre to as much as 129 pounds/acre. Reductions in phosphorus ranged from 3 to 106 pounds/acre. The extremely large reductions in nutrient applications tended to occur in projects where land application of animal waste from large, concentrated poultry operations had previously been for disposal rather than to supply nutrients for crop needs.

Total annual reductions resulting from implementation (compared to estimated pre-project baselines) as of FY 1994 were an estimated 22.3 million pounds of nitrogen and 10.3 million pounds of phosphorus, based on multiplying reductions in average application rate times the land area where reductions occurred in each project. These values are likely to be underestimates because reductions in DPs are reported only for demonstration sites and do not account for practice adoption on non-demonstration sites. The actual significance of these reductions is limited by inadequate knowledge of baseline application rates and continued adherence to new management practices.

Nutrient budget worksheets and other nutrient and/or pesticide planning documents developed by project staff were widely used to estimate changes in chemical applications. About one-third of the projects collected producer data on actual changes in agrichemical use via surveys or interviews. Some DPs were able to very tightly monitor agrichemical applications on demonstration sites. Many project reports noted that improvements in nutrient applications, e.g. split application of nitrogen fertilizer, do not always mean appreciable reductions in total quantity applied on an annual basis, even though potential ***losses*** are reduced through improved management.

Eight projects included pesticide management as a treatment priority. Reporting on changes in pesticide use and/or applications was variable. For the most part, changes were reported quite generally. For example, one HUA reported:

- 10-30% reduction in atrazine use
- 25-50% reduction in alachlor use
- Increase in use of post-emergence pesticides
- Increase in pest scouting

Several reports correctly emphasized that evaluation of changes in pesticide use is far more complex than for nutrient use. Improvements in pesticide management may include changes in formulation or selection of pesticides with reduced leaching or runoff potential. The type, rate, and method of pesticide application may also vary from year to year in response to changes in crop, weather, pest pressure, and other factors. None of these changes would necessarily be reflected in total pounds of active ingredient applied. Information necessary to make inferences about overall improvements in pesticide use among the assessment projects is not available.

A few projects did, however, report quite detailed information on changes in pesticide use; an example from one DP is shown in Table 3.6. While total pounds of active ingredient decreased by a net 9288 pounds (summing the + or - values in the last column), this is not a particularly meaningful number. Substantial decreases in application of some high and medium leaching potential pesticides were noted, e.g. atrazine and alachlor, along with some increases in use of low leaching potential pesticides such as phorate and terbufos.

However, there were significant increases in use of new pesticides with unknown leaching potential, such as acetachlor and dimethamid, making the net effect of management changes difficult to assess. Simulation models would be highly applicable to such assessment since input parameters concerning chemical behavior, such as pesticide partition coefficients or half-life, are known from product registration. It should be noted that the information in Table 3.6 is taken from only one of 20 such pesticide tables presented in the DP's annual progress report for different crops in the project area. Each of these tables would have to be closely analyzed in order to draw conclusions on project impacts. To quote from this project's FY 1994 report:

> Changes in the pounds of individual pesticides applied can be measured, but direct impacts on water quality as a result of pesticide application timing, placement and pesticide family are difficult to measure. Specific pesticide applications change from year to year, depending on a variety of factors such as crop, pest pressure, weather conditions, economics, participation in government programs and others. For this reason it is difficult to accurately compare pesticide rate reductions on a selected field from one year to the next.
>
> It is not accurate to total the active ingredients of all pesticides applied to measure the changes in pesticide usage and derive a net change in usage. Each pesticide has a unique set of chemical traits, including solubility, half life, leaching potential and runoff potential that must be evaluated individually. Many of the newer pesticides are labeled for application to crops at much lower rates due to their high levels of activity. The impacts of this new generation of pesticides is not known; many do not yet possess leaching potential ratings.
>
> The impact of IPM practices to protect the environment are significant, but they cannot be quantified in the pesticide use reduction tables prepared for this report. For example, a producer through effective field scouting was able to make a more timely pesticide application, resulting in a more effective and economical control of the pest. Timely pest control maximizes pesticide effectiveness and reduces potential environmental impacts by eliminating the need for a follow-up pesticide application.[4]

A full assessment of the impact of improvements of pesticide use and application would, therefore, require consideration of soil/water partition coefficient, toxicity, persistence, and other factors, as well as simple reporting of application rates.

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[4] Anoka Sand Plain Water Quality Demonstration Project FY 1994 Annual Progress Report

Table 3.5. Reported changes in average annual nutrient applications on land with practice adoption.

Project	Purpose[1]	Nitrogen Reductions lb/ac	Phosphorus Reductions lb/ac
AL HUA	N,P	129	106
IN HUA	N,P	21	30
MI HUA	N,P	41	18
NY HUA*	N,P	14	21
UT HUA	P	---	0
DE HUA	N,P	118	96
IL HUA	N,P	117	36
OR HUA	N	52	---
MD DP	N,P	43	42
NC DP*	N,P	72	n/a
WI DP	N,P	78	18
FL DP	N,P	14	3
MN DP	N,P	30	21
NE DP	N	21	---
TX DP	N,P	21	18
CA DP	N,P	47	11

[1]Nutrients to be controlled as project objective: N=Nitrogen, P=Phosphorus

--- = Not applicable
n/a = Data not available
* Data from FY 1993 annual report

Source: Projects' FY 1994 or FY 1993 annual report tables V-D.1 and V-D.2. Only includes reductions on monitored demonstration sites in DPs.

Table 3.6. Minnesota DP: More effective use or application of pesticides for corn.

Pesticide	Leaching Potential	Acres Treated Before	Acres Treated After	Pounds of Active Ingredient Before	Pounds of Active Ingredient After	Pounds of Active Ingredient Change[1]
Acetachlor	Unknown	0	395	0	387	+ 387
Alachlor	Medium	1155	291	2771	650	- 2121
Atrazine	High	2976	2872	3127	2546	- 581
Bromoxynil	Low	430	593	164	133	- 31
Cyanazine	Medium	1670	1420	1886	1311	- 575
Dicamba	High	669	828	280	202	- 78
Dimethamid	Unknown	0	360	0	340	+ 340
EPTC	Low	247	8	1175	35	- 1140
Metolochlor	High	1086	963	1311	1299	- 12
Nicosulfuron	High	942	1678	26	46	+ 20
Paraquat	Low	269	0	129	0	- 129
Pendimethalin	Low	1721	1360	1656	1326	- 330
Phorate	Low	159	274	78	147	+ 69
Tefluthrin	Unknown	25	25	2	2	0
Terbufos	Low	173	0	156	0	+ 156
2,4-D	Medium	78	8	39	4	- 35

[1] A (-) sign indicates a reduction in total pounds applied.
A (+) sign indicates an increase in total pounds applied.

Source: Table V-D.3.a, Anoka Sand Plain, MN FY 1994 Annual Progress Report

3.1.5 Findings and Recommendations

Summary of findings:

- There was substantial producer adoption of conservation practices among the Assessment projects, including 134 different practices installed.

- The most prevalent practices adopted were those associated with nutrient management, irrigation water management, cropland erosion control, and animal waste management.

- Among HUAs, implementation met or exceeded project goals for about half of the specified practices. Reasons for slower adoption of some practices were not systematically documented. In some DPs where non-demonstration site adoption was successfully tracked, there was extensive adoption of conservation practices beyond the demonstration sites.

- Targeting of treatments to critical problem areas was generally accomplished and used a variety of approaches ranging from informal local staff knowledge to aerial inventory to collection of water quality data. Quantitative documentation of targeting, however, was generally limited to pest management practices.

- Appreciation for and accomplishment of land treatment tracking grew among Assessment projects over the course of the program. In addition to using the ADSWQ software for practice reporting, some Assessment projects engaged in more sophisticated tracking approaches that included GIS and input files built for simulation models.

- Substantial improvements in nutrient applications were reported: reductions of 21.7 million pounds of nitrogen and 10.2 million pounds of phosphorus. Changes in pesticide use were more difficult to evaluate because improvements involved changes in formulation, timing, and application method, as well as reductions in total quantity.

Recommendations :

- Future land treatment/water quality programs should include guidance with respect to specific performance measures and use of these measures to evaluate project effectiveness.

- Future water quality projects, whether of the DP or HUA type, should include quantitative goals for adoption of land treatments and agrichemical management improvements, based on best available estimates of changes required to protect or improve water quality in the identified receiving bodies.

- A practice implementation accounting system is needed that, to the extent possible, records all practice implementation in the project area, regardless of annual vs. multi-year, presence or absence of technical assistance, demonstration vs. non-demonstration site, in order to measure actual, on-the-ground progress toward project land treatment goals that may affect water quality.

- User-friendly software needs to be made fully accessible to project staff that would facilitate recording of adoption of practices and systems of practices, their locations relative to water bodies, their annual cost, and their performance relative to protecting and improving ground and/or surface water quality. The ADSWQ software developed for this Assessment and the NRCS Field Office Computing System (FOCS) should be critically reviewed in this regard.

- Systematic, objective, and credible procedures to identify critical pollutant source areas should be identified. Project sponsors should target their assistance to landowners and operators in these critical areas.

3.2 Use of Models to Simulate Pollutant Load Reductions

Issues surrounding the use of simulation models to project physical effects due to adoption of conservation practices and changes in agrichemical management, as well as recommendations pertaining to the use of models were presented in the Interim Physical Impact Assessment (Sutton et al., 1993). Reviews of the projects' FY 1994 annual progress indicated that revision of those issues and recommendations was not warranted. The updated content of this section reflects only minor change from previously published analysis.

The physical process simulation models used in the Assessment projects were of two types:

Field-scale models. These models generally represent a homogeneous land unit like one field with the same soil, weather, crop rotations, topography, management, and chemical inputs. Such models help analyze "on-site" problems, i.e. nutrient and pesticide leaching below the bottom of the crop's root zone and surface runoff leaving the edge of the farm field, as well as on-site solutions. They do not directly address changes in the quality of the receiving waters, but do address potential change in pollutant loadings to water bodies attributable to practice adoption.

Watershed (or basin) scale models. These models are used to help analyze off-site problems such as the location of nutrient sources and the quantity and timing of pollutant loadings reaching water bodies, as well as, concentrations within water bodies.

The Florida DP used a model that addresses ground water loadings and flow.
There were no other models readily available to project staff which simulate the effects of management practices on the movement of potential agricultural pollutants reaching the groundwater, as well as, the impact on groundwater pollutant concentrations.

3.2.1 Use of field-scale models. The FY 1994 annual reports showed that, over the 5-year period, staff in four of the projects (AL, MN, TX, and WI) demonstrated a very high degree of competency in model use. Competent use encompasses ability to properly run and calibrate models, clearly document results, and draw logical conclusions that relate directly to the goals of the particular project. Three annual reports (DE, NC, and UT) also indicated substantial growth and level of competency in model use. In one project (CA) that operated an extensive water quality monitoring network, modeling was of limited need. One annual report (FL) which had reported extensive modeling in earlier years could not be obtained in time for this assessment. The remaining reports showed only marginal or no use of modeling.

Table 3.7 shows that EPIC was used by 11 projects. Other models used included NLEAP (four); GLEAMS (three); BARNY and CMLS (two each); and CREAMS, PSIAC, and SPUR (one each). Eight projects used a first-level screening tool to help target land treatments to vulnerable areas. The most commonly used was SPISP or its automated version, NPURG. Both help develop information on which soil-pesticide combinations have the greatest potential for pesticide leaching or runoff.

Generally, models were not run by project field office staff (see Table 3.8). This is understandable given a) the expertise and responsibility of field staffs to plan and assist with implementing conservation practices directly with producers; b) the complexities of learning which of several models may be most appropriate; and c) the difficulty of choosing what data to obtain, how to obtain data cost-effectively given limited staff time, and how to run the model and interpret the large quantities of output. However, moving model operation away from field staffs has potential hazards of which those responsible need to be particularly aware. Interpretation and use of output simulations without careful thought may show improbable results, a consequence that can quickly - and at times unjustifiably - damage model credibility and preclude further use of a potentially valuable analytical tool. Although not obvious from the table, it may be significant to mention that in those projects whose annual reports cited simulated changes between pollutant loadings and agricultural practices, university staffs were closely involved in model use. Three of the six projects contracted out modeling work to university staff.

Table 3.7. Simulation model usage by project.

	HUA Project State								Demo Project State							
Model	AL	DE	IL	IN	MI	NY	OR	UT	CA	FL	MD	MN	NE	NC	TX	WI
AGMAN						p										
BARNY						u										u
CMLS							u			u				p		p
CREAMS											u			p		
DRAINMOD									p							
EPIC		p	u	u	u	p	u	U		u	u		u	U	U	u
FIRI								u								
GLEAMS	U	p	p				u			p		U				
NLEAP		u	p	p		p	u			p		U	U			
NPURG							u									
PSIAC								u								
SPUR															u	
AGNPS	u	U		u	u			u							U	U
GWLF						u										
SWRRBWQ			p		p	p									u	u
VS2DT										u						

U - model used, results reported in 1994 report; u - model used but no results reported in 1994 report; p - planned for use during project life.

Source: Sutton et al., 1993 and FY 1994 reports

Table 3.8. Organizational level of model operation.

-----------NRCS-----------		--------CES--------		-----Other----
Project Office	State Office	Project University Office	State and Staff	Federal
FL	AL	UT	FL	AL
OR	DE		IN	TX
TX	IL		MD	
AL	IN		MN	
	MD		NE	
	MI		NY	
	MN		NC	
			WI	

AL and MN also received assistance from regional technical staff of NRCS

Source: Sutton et al., 1993

Because of the simplifications and assumptions that these tools incorporate to simulate highly complex real-world physical processes, it is important that readers of annual reports understand the significance of model projections. Readers would benefit if annual reports cited, along with modeled numerical results:

- the model used and the number of years in the simulation;
- both the previous and new agricultural system being simulated;
- the representativeness of the soils and systems modeled;
- confidence/accuracy/probability discussion;
- changes in leaching/runoff of other pollutants that may have accompanied the reductions in the pollutants of most concern; and
- significant model strengths and limitations.

The projects' intensive use of models has been particularly valuable in that use has revealed that there are agricultural practices and/or issues: a)that the models do not address; b)that cannot be addressed usefully unless the model has been validated and verified to local conditions; and c)that can only be addressed with difficulty because model documentation is not clear.

The following practices and/or issues are among those deemed not well addressed by the field-scale models, CREAMS, EPIC, GLEAMS, and/or NLEAP. Not every item applies to every model: animal grazing; nutrient and pesticide banding; buffer strips/riparian zones; grassed waterways; interactions between pesticides; flood-irrigated rice; furrow irrigation; gully erosion; high water tables; maximum contaminant level warnings; minor but high value crops (e.g. vegetable and citrus); mixed plant populations; nitrogen inhibitors; pesticide emulsifiers, stickers, and wetting agents; pest population dynamics; rangeland; stochastic input/output (variability); subsurface drainage; subsurface flow (base flow); trickle irrigation; pesticide and nutrient volatilization; wetlands.

3.2.2 Use of watershed-scale models. The annual reports of three projects (WI, UT, and TX) demonstrated that project staff developed significant expertise in understanding and discussing how modeled results portray the ability of conservation practice adoption and agrichemical management changes to affect basin scale pollutant loadings. Four other project demonstrated a modest gains in modeling skills. Most projects did not use a watershed-scale model.

Watershed-scale models such as AGNPS and SWAT are subject to many of the same types of limitations noted for field-scale models. Project staffs indicated several additional issues: need to convert AGNPS to a continuous system (more than one storm event); linkage of model outputs to a geographic information system (GIS); and an output notice when Maximum Daily Contaminant Levels are exceeded.

3.2.3 Findings and Recommendations

Summary of findings:

- Staff in about half of the projects where modeling was applicable demonstrated substantial competency in field-scale model use. The most widely used field-scale model was EPIC. Few project staffs (3) demonstrated skill in use of watershed-scale models. AGNPS was the most widely used watershed-scale model.

- Use of university staff, NRCS state or regional office staff, and project office staff to run the models differed among projects depending on availability of appropriate resources and expertise.

- Eight projects used a first-level screening tool to help target land treatments to vulnerable areas. The most commonly used was SPISP or its automated version, NPURG. Both help develop information on which soil-pesticide combinations have the greatest potential for pesticide leaching or runoff.

Recommendations:

- USDA agencies should continue to emphasize development of staff capabilities to choose appropriate simulation models, both field-scale and watershed-scale, acquire reliable input data at least cost, and use selected models properly, including output interpretation and sensitivity analysis. Given the significant time required for an individual to become able to quickly and effectively use models in project planning and in simulation of future water quality effects, agencies should focus training on a cadre of individuals who could assist multiple projects.

- Project staff should secure the assistance of these trained experts to use appropriate models in the project planning process to help identify critical pollutant source areas, the nature of the pollution problem, design of water quality monitoring, and potential effects of alternative management systems on pollutant loadings.

- Agencies should continue to place a high priority on development of and training in the use of screening tools for leaching and runoff of nitrogen and phosphorus, and for sediment production to assist in identification of potential pollutant source areas and areas to target for management improvements.

3.3 Water Quality Monitoring

Unlike the estimation of changes in agrichemical inputs or the use of simulation models to predict changes in losses of sediment, nutrients, or pesticides from agricultural land, water quality monitoring can, if conducted properly, document actual changes in receiving waters impacted by agricultural nonpoint source pollution. Monitoring can define physical conditions, chemical concentrations and loads, and the status of biological communities. Monitoring is considered to be the most convincing and defensible means of documenting water quality response to management changes. (Gale et al., 1992; Coffey et al., 1993). While ET&FA policy recognized the importance of water quality monitoring, it encouraged project staffs to concentrate on their own expertise in land and agrichemical management and rely on the expertise of other Federal, State, or regional agencies to plan, fund, and conduct water quality monitoring. Thus, monitoring was not designed specifically into any of the Assessment projects. However, most of the projects did ultimately engage in some form of water quality monitoring, generally added after project inception.

3.3.1 Description and status of monitoring. Fourteen of the 16 projects used water quality monitoring of some kind to help evaluate project effects. These efforts have been described and analyzed previously (Sutton, et al., 1993; Meals and Sutton, 1994). Monitoring programs varied tremendously among the projects, but generally relied on state, regional, or federal agency programs of several types:

- Ongoing ambient monitoring programs designed for other purposes and which happened to include some stations within the project area (e.g the CA and FL DPs, DE and UT HUAs);

- Short-term intensive programs focused on a specific area or problem that overlapped the project area (e.g. MD and WI DPs); and

- Specialized programs designed for the project, including both site-level and watershed monitoring (e.g. OR and MI HUAs and CA and NC DPs).

Principal participating Federal/regional agencies included the USGS, USDA-ARS, and the TVA. Researchers from state universities and from Agricultural Experiment Stations participated in some monitoring efforts. State-level regional organizations such as Natural Resource Districts in Nebraska and county agencies in Indiana also contributed to monitoring.

3.3.2 Water quality monitoring workshop. USDA-NRCS sponsored a Water Quality Monitoring Workshop in 1993 at the University of Vermont to enhance abilities of project staff to plan and implement monitoring networks in land treatment projects and to improve knowledge and skills needed to effectively collaborate with water quality monitoring agencies. The workshop focused on the steps necessary in design and operation of an effective monitoring study, including problem definition, sample collection and analysis, land use monitoring, and data analysis. The training sequence was built around the draft NRCS Water Quality Monitoring Manual (Clausen, 1993).

Most of the 16 projects sent participants. Each participant was given a post-workshop assignment to apply the knowledge acquired in the workshop by evaluating the water quality monitoring system in one of the Assessment projects, or to formulate a monitoring plan if none existed. In some cases, the completed assignments were evaluations of existing monitoring programs; in a few cases, project staff developed a detailed proposal for a major monitoring plan to evaluate project effects and submitted the proposals for external funding.

Analysis of the completed assignments suggested that important knowledge/perspective was gained at the workshop with regard to good water quality monitoring design. Significant learning points included: the importance of a good problem statement as a foundation for monitoring program design; how to set clear objectives, crucial in determining the ongoing effectiveness of a monitoring program; technical design of monitoring networks; monitoring data evaluation; and the need for significant land use/agricultural activity monitoring. Knowledge of the essential elements of a good monitoring program is important and should allow project personnel to interact more effectively with monitoring agencies in future projects and ensure water quality monitoring is more fully included in the project mainstream.

3.3.3 Results of water quality monitoring. Assessment of project impacts through water quality monitoring is very difficult if the monitoring program is conducted separately from the land treatment program and especially if it is added after the project has begun. Despite some serious flaws in the use of water quality monitoring for project impact assessment, it is important to recognize that most project monitoring efforts contributed in some way to project operation and evaluation of project effects.

The approach to monitoring differed markedly between HUAs and DPs. Because they concentrated on a few intensively managed demonstration sites, monitoring in DPs generally focused on evaluating the effects of specific practices and did so with some success. However, DPs were generally ill-equipped to evaluate project effects because: 1) they did not typically track implementation on non-demo sites; and 2) they were usually located in undefined hydrologic areas (i.e. counties rather than watersheds). HUAs, on the other hand, usually lacked the focus and control on individual sites critical to practice monitoring but were potentially better able to evaluate watershed or project level water quality because they were situated in distinct watersheds.

Monitoring efforts fell into three types: 1) individual practices or demonstration sites; 2) watershed-scale baseline data or characterization; and 3) project effectiveness. Selected examples are discussed below. This discussion does not purport to present a complete catalog of all monitoring activities carried out among the Assessment projects.

Monitoring at Practice/Demonstration Sites

Evaluation of practice performance at the edge-of-field-scale through monitoring is a critical ingredient in land treatment/water quality projects. It is, for example, essential to know that a practice can reduce pollutant losses to receiving waters and be practical at the farm level before implementation throughout a project area. While it is not necessary to prove the effectiveness of practices repeatedly or in every project, testing of new practices can suggest that overall water quality response to the project can occur. This knowledge can be important in "selling" new practices to landowners and to the public. Such practice monitoring was conducted successfully by many projects.

Individual site or practice monitoring is only an indirect measure of project effectiveness, because the link between practice installation and watershed-level or receiving body water quality improvement has been extremely difficult to establish, even in projects with intensive monitoring and evaluation. The Rural Clean Water Program is a case in point (NWQEP, 1993). Therefore, practice or site monitoring should be considered necessary, but not sufficient to overall project impact assessment.

Seco Creek Water Quality DP, Texas
Monitoring by the Texas Agricultural Experiment Station and by DP field office staff using plots or small paired watersheds has been used to evaluate actual impacts of several practices on water quality. Examples include:

- Evaluation of the effectiveness of spring enhancement documented no deterioration of water quality while significantly increasing spring flow.

- Evaluation of native vegetation filter strips to reduce sediment and nutrient losses from cropland showed potential for significant reductions of sediment delivery from cropland to streams.

- Paired watersheds[5] were established to investigate effects of brush removal on rangeland hydrology.

- Assessment of the effectiveness and fate and mobility of herbicides applied for brush management through monitoring of herbicide residues in soil and runoff from plots.

Anoka Sand Plain Water Quality DP, Minnesota.
The University of Minnesota Agricultural Experiment Station's Sand Plain Research Farm has conducted several water quality studies, including:

- Monitoring nitrate leaching from irrigated potato production demonstrated effective nitrogen management leading to reduced nitrate leaching potential with no losses in marketable yield;

- Assessing soil nitrogen availability tests to determine the applicability of diagnostic soil nitrogen tests and the optimum time/depth of sampling for effective nutrient management to control nitrate leaching.

DP staff worked with University of Minnesota researchers for several years on extensive vadose zone soil-water monitoring utilizing fixed tube suction samplers. In general on sandy soils, changing from conventional nitrogen management for potatoes to improved nitrogen management based on University recommendations resulted in lower nitrate levels in the soil water solution.

The DP had a "Management Systems Evaluation Area" (MSEA) site within its borders. Monitoring of atrazine losses to groundwater from ridge-tilled corn-soybean rotations at the MSEA site have shown no atrazine below 1.5 feet, suggesting the effectiveness of this practice in preventing atrazine from reaching the surficial aquifer.

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[5] The paired watershed approach is a powerful experimental design which controls for meteorologic variation and allows for effective determination of treatment effects (USEPA, 1993)

The Minnesota Pollution Control Agency (MPCA) is monitoring nitrate levels in groundwater associated with implementation of nutrient management and other BMPs on one demonstration farm. Because of the high variability observed in groundwater nitrate concentrations, MPCA personnel estimate that it will be 5-10 years before trends can be well documented. Even then, the lack of pre-project data from the site makes it doubtful that trends can be attributed directly to the BMPs.

DP personnel cite BMP effectiveness monitoring/research as a major need in the project:

> There is a lack of research being conducted, both privately and publicly, to determine if current BMP's are economically sound and environmentally adequate on the Anoka Sand Plain, making it difficult to sell these practices. The practices we are promoting have not been extensively researched on sandy soils in east central Minnesota.......More site and situation specific information is needed particularly in reference to pesticide rates, nutrient requirements and crop water use/irrigation requirements to properly assist producers.....[6]

Unfortunately, the BMP and site monitoring described above has actually contributed relatively little to fill this need. Most of the activity of the Sand Plain Research Farm is concerned with yield and other agronomic problems, and most of the research on the MSEA site is not directly applicable to the conservation practices promoted by the DP. Clearly, the MPCA study will not provide results quickly.

Herrings Marsh Run DP, North Carolina.
USDA-ARS and North Carolina State University studied treatment of swine waste by a constructed wetland. In the first year of operation, monitoring documented removal of 90% of nitrogen and 80% of phosphorus on a mass basis. However, declining phosphorus removal in the second year raised questions about the sustainability of waste treatment using the constructed wetland alone.

The results of this monitoring study may be quite valuable for future waste treatment implementation, but actual utility for DP impact assessment is low because implementation of other such systems did not occur.

Water Quality DP - East River, Wisconsin.
Two research/monitoring efforts focused on milkhouse waste management. In 1992, a three-year project was undertaken to evaluate the use of a constructed wetland to treat milkhouse waste in a northern climate and to establish design parameters for effective constructed wetlands. Preliminary results showed substantial reductions in phosphorus, nitrogen, BOD, and COD with passage through the wetland, and showed that weather plays a major role in wetland function.

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[6] Anoka Sand Plain Water Quality Demonstration Project, FY 1994 Annual Progress Report

A second study on two farms evaluated the potential of a water-conserving milking center sink to reduce total water and energy use and pollutant discharge. The study found that wastewater BOD and phosphorus levels decreased significantly with use of the sink (Urhig and Moore, 1995).

While both of these studies provide important data on practice performance, their actual value for the DP was small since reported adoption of the two practices evaluated was minimal. The monitoring work may, however, have long-term impact on adoption due to demonstration of the effectiveness of these new practices.

Lake Manatee DP, Florida.

Monitoring conducted by Manatee County Extension staff and by the University of Florida/IFAS Agricultural Experiment Station has provided definitive information on nitrate accumulation and movement in shallow ground water under vegetable and citrus production demonstration sites. Monitoring projects used piezometers around fields and groves and multilevel wells within fields and groves to measure nitrate and soluble phosphorus in groundwater.

This work has been instrumental in identifying critical times in the cropping season when peak nitrate levels occur: bed preparation, major rainfall events, supplemental fertilizer application, and removal of plastic mulch at the end of the growing season. In addition to providing important guidance for improved irrigation management, this demonstration site monitoring helped to target management efforts by identifying deeply-rooted citrus groves as sites where off-site nutrient movement is most likely to occur. The monitoring studies also demonstrated that, as improved management practices are adopted, the incidence of excessive nitrate levels in groundwater declines. These data are useful in projecting DP impacts and in "selling" improved management practices to producers. For drip-irrigated vegetables, for example, careful water and fertilizer management led to 95% of ground water samples with less than 1 mg/l nitrate-nitrogen, compared to 74% of samples exceeding 10 mg NO_3-N /l beneath a poorly managed site.

The high level of coordination among players in this DP ensured that the site monitoring data were used well in the overall project, e.g. for improved targeting and for providing feedback to producers. This is one of the critical functions that water quality monitoring can serve. As in other DPs, the utility of this site monitoring in assessment of project impacts depends on the extent of adoption in the project area, which in this project may be insufficient to affect overall nutrient loading to the reservoir within the project time frame. A reservoir monitoring program being conducted by the Manatee County Public Works Department might be useful in long-term trend detection; however, these data have not yet been compiled and reported by the DP.

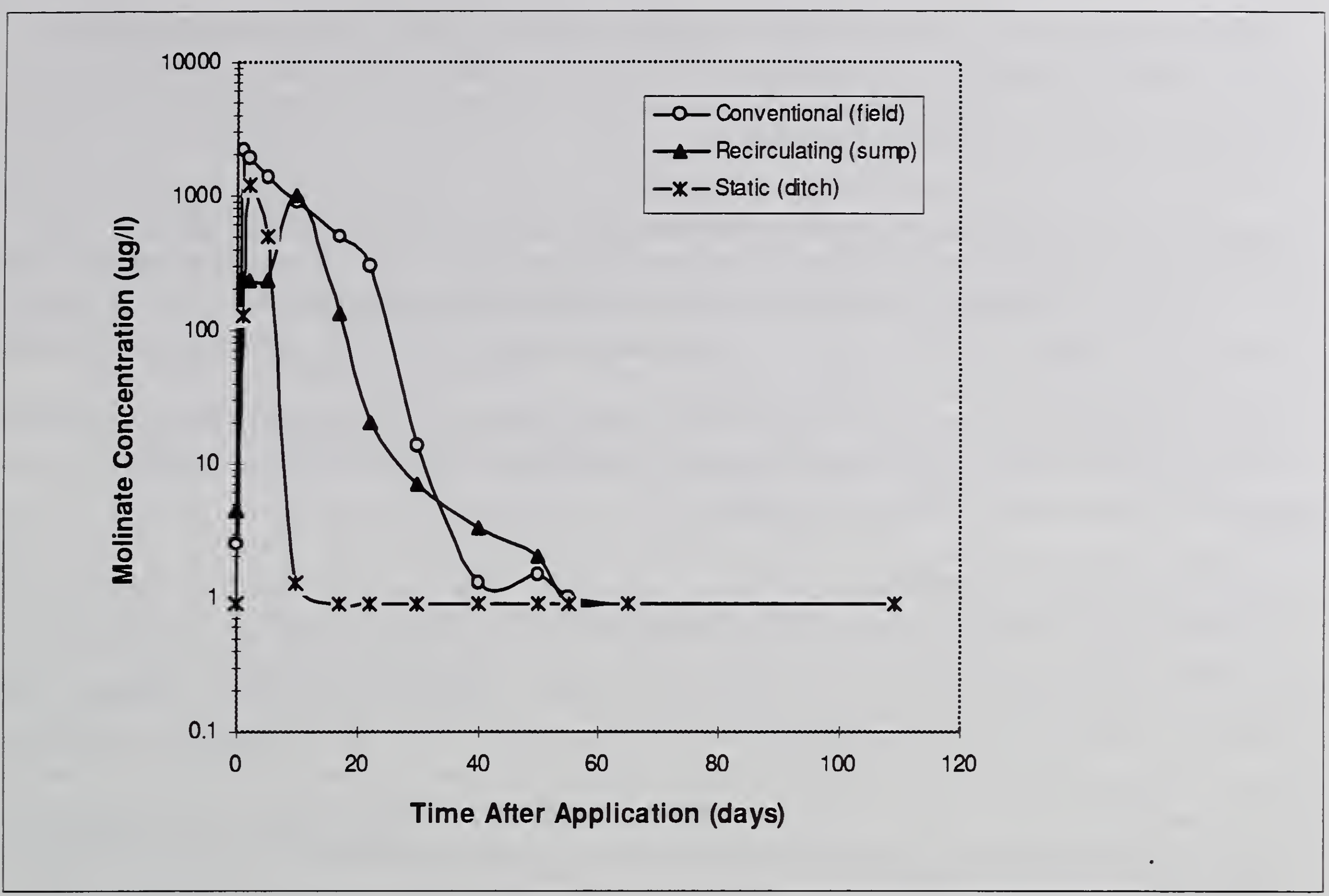
Sacramento River Rice Water Quality DP, California.
One objective of this DP was to demonstrate the effectiveness of two novel water management systems - static and recirculating - designed to reduce off-site pesticide movement from irrigated rice cropland to the Sacramento River. The University of California Cooperative Extension Service monitored rice pesticide residue concentrations at three demonstration irrigation system outlets, providing side-by-side comparisons of conventional, static, and recirculating rice irrigation systems. Levels of molinate (the primary pesticide used) measured at the recirculating system outlet were generally lower than those measured at the conventional system outlet (Figure 3.1). Peak molinate concentrations measured in the recirculating system were 1030 ug/l, compared to 2150 ug/l in the conventional system. By the end of the tailwater holding period, molinate in the recirculating system was 93% lower than in the conventional system. One week after application, molinate concentrations in the static system outlet were much lower than those at either the conventional or the recirculating system outlets; no molinate was detected in the ditch for the remainder of the season. At one of the monitored demonstration sites, the seasonal mass discharge of molinate from the static and recirculating systems were 97-99% and 76-96% lower, respectively, than levels from the conventional system (Colusa site, 1991 and 1992).

Unlike some of the specific practice monitoring in other DPs, the static and recirculating irrigation systems were widely installed in the DP: 51 recirculating systems serving 19,000 acres and 56 static systems serving 5,700 acres. Thus, the strong documentation of practice effectiveness provides a convincing first step in showing that implementation in the project area has the potential to affect water quality in the Sacramento River.

Watershed Baseline/Characterization Monitoring

Watershed-scale monitoring efforts in several projects have been unsuccessful in documenting project impacts, either because the monitoring was not designed specifically to evaluate the project or because the hydrologic system is not conducive to assessing project impacts through monitoring within a short time frame. Nevertheless, such monitoring has in several cases resulted in basic characterization of water quality or in baseline/pre-treatment data which may contribute to future documentation of project effects. While this approach is not usually a strong one for evaluating the impacts of land treatment on water quality, these monitoring efforts have built data bases potentially useful in future assessment of project effects.

Sand Mountain/Lake Guntersville HUA, Alabama.
The Alabama Department of Environmental Management (ADEM) has conducted an extensive water quality monitoring program within the HUA since 1988, consisting of monthly monitoring at eleven stations for physical/chemical parameters including dissolved oxygen, turbidity, suspended solids, BOD, phosphorus and nitrogen forms, and fecal coliform bacteria.



Sacramento River Rice Water Quality DP, FY94 Annual Progress Report

Figure 3.1 Molinate concentrations measured at the outlets of the three irrigation systems (Colusa site, 1991)

It is difficult to assess the actual utility of this program since no data were reported in the FY 1994 annual progress report. The data are currently being analyzed by ADEM and TVA. ADEM suggests that, in the absence of long-term historical data, the current data base serves as a good baseline from which to measure change. The lack of storm event sampling in this monitoring program is a major drawback because most non-point source water quality problems occur during runoff events rather than during base flow. Additional event-based sampling had been discussed in the past, but could not be accomplished due to lack of resources.

Other monitoring activities included pre-project biomonitoring in tributary streams for fish communities conducted by TVA and benthic macroinvertebrates by EPA and reservoir monitoring by TVA. Post-project biomonitoring could help document changes resulting from the HUA project, but its likelihood is uncertain.

While the TVA reservoir monitoring program is very well suited to tracking long-term water quality trends, the very small contribution of the HUA to the water and nutrient budgets of the reservoir suggests that changes in overall reservoir water quality in response to land treatment in the HUA are unlikely.

Even though this project had a substantial level of associated monitoring, there has been essentially no analysis or evaluation of these efforts in project annual progress reports. This omission is perhaps symptomatic of a lack of interaction between land treatment and water quality monitoring activities, a common pattern in Assessment projects that relied entirely on outside agencies for monitoring and evaluation. This means, at the very least, that readers of project reports have no idea what is being seen in the impaired water resource, and more importantly, that the land treatment effort does not benefit from valuable feedback from water quality monitoring.

Inland Bays HUA, Delaware.
Extensive ground water studies have been conducted in the project area by University of Delaware, Delaware Department of Natural Resources and Environmental Control, the Delaware Geological Survey, and the USGS since 1977. Wells in agricultural, forested, and residential areas have been monitored for nitrate-nitrogen, with the highest nitrate levels usually associated with poultry producing areas and the lowest observed in forested areas. Recent work has shown that more than 70% of all wells in the water table aquifer have detectable concentrations of nitrate and 15% of wells have nitrate levels exceeding the EPA MCL of 10 mg/l. The Delaware Geological Survey suggests that up to 356 pounds/day and 2180 pounds/day of nitrate into Rehoboth Bay and Indian River Bay, respectively, in direct ground water discharge (Andres, 1992).

All studies have shown extremely high variability in ground water nitrate concentrations. This variability, coupled with the very long time of travel estimated for movement of nitrate from agricultural land to the Bays (50-100 years is not unusual) and the fact that the monitoring was not targeted to the land treatment areas, make it essentially impossible to document water quality effects due to the project through short-term ground water quality monitoring. However, the extensive nitrate concentration data set and the knowledge of the regional ground water system will serve as a strong data base for future evaluation.

Ontario HUA, Oregon.
This HUA has been designated as a Groundwater Management Area under Oregon law due to excessive levels of nitrate in ground water. There is a considerable documentation of the regional groundwater system and an areawide monitoring program. There have been extensive studies of the hydrogeology of the area and of nitrate and pesticide contamination of the vadose zone and groundwater.

The Oregon Department of Environmental Quality (DEQ) monitors groundwater quality bi-monthly in a network of 38 wells in the Ontario area as part of a ground water management action plan for northern Malheur County. There were, however, no data from this program included in the HUA FY 1994 report and the data have apparently not yet been evaluated by Oregon DEQ. The monitoring program has been extended for three years, although given the nature of the hydrologic system, it seems unlikely that changes will be detected in that time frame. Because of the complexity of the hydrogeologic system, this present monitoring program is not well suited to evaluating the effectiveness of changes in agricultural management in the HUA.

The relationship between changes in agricultural practices and groundwater quality is not well understood in the complex hydrogeologic system underlying the HUA. There are multiple recharge sources to the aquifer, large quantities of nitrate in the vadose zone above the aquifer, and the relationship between nitrate loading in the vadose zone and nitrate levels in groundwater is essentially unknown. In addition, slow ground water movement suggests that significant changes in nitrate levels are likely to take 10 to 20 years in the HUA. Thus, assessment of physical impact of the project through monitoring is unlikely in the near term, although the data do provide a reasonable baseline characterization to work with in the future.

Little Bear River HUA, Utah.

Because this project area was also designated as a state 319 Nonpoint Source Project area, the Utah Department of Environmental Quality (DEQ) conducted a detailed water quality assessment of the Little Bear River watershed in the early stage of the HUA project. This assessment was generally designed to provide information on designated use support, evaluate water quality trends, and determine critical water quality issues to be addressed; the effort was also aimed at assessing background data for determining the effectiveness of the HUA project.

The DEQ assessment included intensive sampling from 1990 through 1992, consisting of physical/chemical monitoring at 17 sites for a full range of parameters, including sediment, nutrients, metals, and pesticides. Benthic macroinvertebrate communities were evaluated at three sites. The study concluded that surface waters in the watershed were only partially supporting designated uses, due to violations of phosphorus, ammonia, and fecal coliform criteria. DEQ recommended that upstream/downstream monitoring be used to evaluate the effectiveness of BMPs because of the existence of point sources in the watershed, that more detailed monitoring be conducted to evaluate seasonal nonpoint source impacts, and that land use be monitored to correlate with long-term water quality changes.

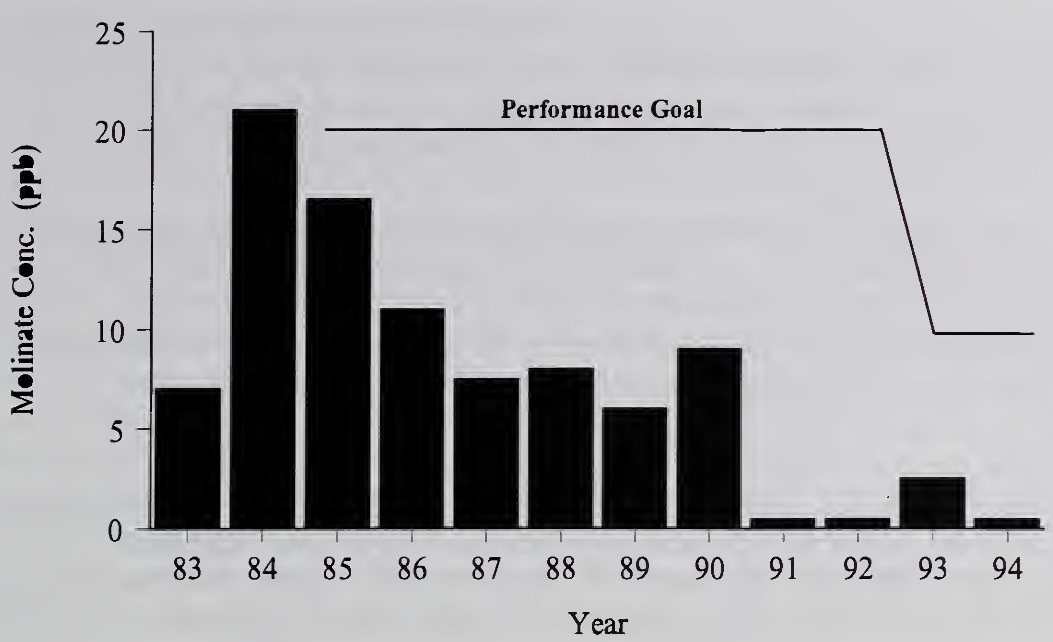
Unlike other projects, the DEQ assessment was included in the HUA FY 1994 Annual Progress Report, and the recommendation for upstream/downstream monitoring of BMPs was followed by HUA personnel. Thus, this monitoring was more closely linked to the overall HUA program than in many other Assessment projects.

Although it was part of a statewide, agency program, the assessment was tailored specifically to the HUA area and its goals were highly appropriate for the HUA project. The data developed can be very useful as background data to evaluate changes due to the HUA project. It should be noted, however, that before/after monitoring at a watershed level is a difficult approach for evaluating the effects of a land treatment program and the approach requires careful consideration of hydrologic variations and land use and management activities.

Seco Creek DP, Texas.
The USGS has collected water quality data from one site on Seco Creek since 1965 and through a cooperative agreement with a state agency, USGS installed 3 new gaging stations in support of the DP. Surface water samples are collected monthly and during major storm events and analyzed for a full range of physical and chemical parameters, including sediment, nutrients, trace metals, and pesticides. These stations provide information for the entire length of the watershed and represent a strong baseline data set. In addition, the USGS has conducted extensive well inventory and ground water sampling in the project area.

Results of this watershed monitoring program are fully reported as an appendix in the DP's FY 1994 annual report. Unlike some other Assessment projects, this monitoring effort was specifically implemented to evaluate the effects of BMPs on protecting the quantity and quality of water in Seco Creek on the watershed-scale. The monitoring program will continue after changes in land management has been fully implemented to determine changes in water quality. For both of these reasons, this characterization monitoring has a good probability of success in detecting project effects on water quality.

Sacramento River Rice Water Quality DP, California.
An extensive surface water quality network is operated in the Sacramento River and tributaries by the Department of Pesticide Regulation to insure compliance with performance goals set for discharges of major rice pesticides. Concentrations of several pesticides are also monitored at the intake of the City of Sacramento water treatment facility. These monitoring efforts provide excellent data on trends in pesticide concentrations in receiving waters (Figure 3.2). While these data are subject to variability due to drought or flood, they do provide an excellent data base for tracking response to improved irrigation tailwater management in the receiving water.



Source: Sacramento River Rice Water Quality DP, FY94 Annual Progress Report

Figure 3.2 Peak molinate concentrations at intake of Sacramento's water treatment facility.

Project Effectiveness Monitoring

A few of the projects initiated monitoring specifically designed to evaluate the effectiveness of the land treatment program. This may have involved engaging the services of a federal agency for work in the watershed, bringing the project into an existing state program as a case study site, actively developing a monitoring proposal for funding, or even sampling conducted by project staff. In each case, however, the effort was designed and implemented specifically to assess project impacts.

<u>Little Bear River HUA, Utah</u>.
Project staff have begun to implement a simple monitoring effort based on the Utah DEQ recommendation for above/below monitoring to evaluate BMP effects. In one case, application of a BMP to a livestock corral resulted in a dramatic improvement in fecal coliform bacteria counts in a stream with passage through the corral:

	Above Corral	Below Corral
	--#/100ml--	
Before BMP	7600	>100,000
After BMP	350	360

In addition, project staff have collected samples for sediment, nutrient, and bacteriological analysis upstream and downstream of six other farm sites where BMP implementation is planned. Comparing these "before" data with additional samples collected after implementation will give some indication of BMP effects on water quality.

This approach is very basic and is unable to account for variations due to precipitation or streamflow changes which could be very important. A single set of before and after samples are inadequate to truly represent before and after conditions; additional above/below sampling would certainly be desirable. However, this kind of very simple, inexpensive monitoring does have some value. First, it does begin to suggest the effectiveness of the practices implemented. Second, it suggests what water quality variables may respond to treatment and, consequently, what variables might be monitored downstream to assess the effects of the entire program of implementation at the watershed outlet. Third, it involves project personnel directly in monitoring and evaluation, establishing an important feedback loop between land treatment implementation and water quality evaluation. Finally, such basic demonstration of the effect of improved management, even if only demonstrated at a single point in time, may provide evidence useful in convincing landowners and the public in the effectiveness of their conservation efforts.

Water Quality DP - East River, Wisconsin.
In 1990, the Bower Creek subwatershed within the East River DP area was selected as a site for a statewide watershed-management evaluation monitoring program conducted jointly by the U.S. Geological Survey and the Wisconsin Department of Natural Resources. The overall objective of the program is, for each individual project, to determine if the water chemistry in the receiving stream has changed as a result of the implementation of land-management practices in the watershed (Corsi, et al., 1994).

The approach taken includes monitoring of water chemistry and associated variables before, during, and after watershed management plans have been completely implemented. Storm load data will be used to evaluate the effect of BMPs by comparing pre-BMP and post-BMP storms. Data are collected for stream discharge, sediment, phosphorus, and selected pesticides. Along with this water quality monitoring, land use and BMP inventory data are being collected under the state's Priority Watershed Program. This land use monitoring effort includes agricultural land use as well as other watershed characteristics and tracks information on implemented BMPs, land uses, and other changing watershed characteristics in a GIS data base.

This is one of the more effective monitoring efforts to be implemented among the Assessment projects and has a very good potential to actually demonstrate changes in water quality in response to the land treatment program. The USDA DP has been officially concluded; it will take some effort, therefore, to make sure that future results of this monitoring effort are incorporated into USDA program management and evaluation consideration.

Monocacy River Watershed DP, Maryland.
This project has benefited from two major watershed-level monitoring efforts conducted within the Monocacy River watershed, making it an exception to the pattern of DPs focusing predominantly on individual practice monitoring. Baseline water quality data have been collected in the Piney/Alloway Creek subbasin by the Maryland Department of Environment, Department of Natural Resources, and the U.S. Geological Survey as part of a statewide cooperative stream restoration program called the Maryland Targeted Watershed Project. The program monitors physical, chemical, and biological water quality parameters and assesses variations due to seasonal and annual hydrologic variation so that water quality changes in response to changes in land use and resource management can be measured.

In the Piney/Alloway subbasin, one automatic sampling station and eight grab sample sites have been operated since 1990. From 1990 - 1991, monitored parameters included suspended solids, phosphorus, nitrogen, BOD, metals, pesticides, fecal coliform bacteria, benthic invertebrates, fish, and toxicity bioassays. Since 1992, only suspended solids, phosphorus, and nitrogen have been monitored. The monitoring program is continuing under funding from the State of Maryland, EPA Section 319, and USGS.

Additional water quality monitoring has been initiated in the Warner Creek subbasin by the University of Maryland Agricultural Engineering Department through EPA Section 319 funding. The purpose of this monitoring is to develop and validate a water quality model for prediction of effects of BMPs on water quality on both a field and a watershed-scale. Ultimately, the model will be applied to evaluate the impact of the DP on the Monocacy River.

The project FY 1994 annual progress report notes that no changes in water quality or impacts in water use have been documented in response to the project, possibly due to time required to fully implement practices and lag time in soil and water system response. However, the monitoring program has been able to provide excellent baseline surface water quality in some of the target areas and, if continued, could document future changes in water quality. Furthermore, the monitoring/modeling activity underway in Warner Creek has good potential to aid in assessment of project impact if it results in an acceptably calibrated simulation model.

Herrings Marsh Run DP, North Carolina.
Several water quality monitoring efforts encompassing both ground and surface water are evaluating the influences of agricultural practices on water quality. Monitoring has suggested decreases in nitrate and ammonium resulting from BMP implementation on cropland and from improvements in animal waste management.

This monitoring documented the water quality effects of dense swine and crop production in some areas of the project area and was also instrumental in revealing an overloaded waste lagoon and in demonstrating the water quality benefits of its remediation (Hunt, et al., 1995). The surface water monitoring program also helped document the effectiveness of an in-stream wetland established in one of the monitored streams.

An ARS ground water monitoring program focuses on pesticide and nitrate analysis of both observation wells on farms and domestic wells (Stone, et al., 1995). While most wells have shown very low nitrate and herbicide levels, nitrate levels exceeded the EPA drinking water standard (10 mg/l) in 22% of the farm wells and in 25% of the domestic wells. Alachlor, triazines, and metolachlor were detected in 50% of domestic wells, with most detects below 1 ug/l. Factors identified as contributing to high nitrate levels and pesticide detections included shallow depth, proximity to cropland, and septic systems.

The NC Division of Environmental Management (DEM) has conducted an annual biological assessment (benthic macroinvertebrates) since 1990 at four stations in order to evaluate the effectiveness of the DP program. The most recent data suggest small improvements in water quality at two Herrings Marsh Run stations, as evidenced by more EPT taxa (groups requiring cleaner water) compared to previous years.

The monitoring efforts in support of this project have a good chance at showing water quality response to the land treatment program. The surface water monitoring program, both the physical/chemical monitoring by ARS and the biomonitoring by NC DEM were specifically designed to help evaluate the impacts of the DP on water quality. The ground water monitoring program is extensive, although it is unclear if enough is known about groundwater hydrology in the area for the program to be useful for trend detection. Coupled with the methods being employed to track land treatment and land use at the subwatershed level, this data base should provide solid evidence of water quality change as a result of the DP if the monitoring is sustained long enough after the DP is completed.

One feature of the water quality monitoring effort in this DP deserves special comment. The integration of monitoring and land treatment in this DP was among the best shown in the Assessment group. Water quality monitoring activities were consistently discussed in the DP's annual progress reports and data were also presented.

The FY 1994 Annual Progress Report, for example, includes a full report of the biomonitoring data from NC DEM. In addition, two recent publications of monitoring work in the DP area (Hunt, et al., 1995 and Stone, et al., 1995) include authors not only from the monitoring agency (ARS) but also from Extension and NC State University, indicating ongoing communication and coordination between land treatment and water quality personnel not found in many of the Assessment projects.

Sycamore Creek HUA, Michigan.
This HUA project has probably the best water quality monitoring program among the Assessment projects and the best chance for successful documentation of project impacts on water quality. Because of a state program requiring nonpoint source evaluation in watersheds with documented water quality standard violations, the Michigan Department of Natural Resources (DNR) participated early in the HUA project and developed a paired watershed design study to evaluate the effects of implementing sediment and nutrient control BMPs on agricultural land. Two sub-watersheds within the HUA area - Willow Creek and Marshall Drain - were selected for treatment, with a watershed outside the project area -Haines Drain - as control.

Streamflow is recorded continuously. Automated samplers are used to sample intensively during growing season storm events, supplementing weekly grab samples collected for trend determination. Water quality variables measured include turbidity, suspended solids, total and soluble phosphorus, and several forms of nitrogen.

This monitoring program is funded by EPA under the Section 319 National Monitoring Program, a nationwide program of selected nonpoint source projects designed to successfully document land treatment effectiveness with respect to water quality (NCSU, 1994). As an approved project under the National Monitoring Program the Sycamore Creek project has met criteria for effective monitoring design that give it an excellent chance of success at detecting water quality response to land treatment. Coupled with the active land treatment implementation and tracking efforts and the information and education activities already in place in the HUA project, this project has the best opportunity among the Assessment projects to show impact on impaired water quality at the watershed level through water quality monitoring.

3.3.4 Findings and Recommendations. The Assessment projects managed to conduct a variety of water quality monitoring efforts aimed at evaluating their impacts on water quality problems. Many of the projects documented the ability of individual practices or demonstration sites to improve water quality. Even where external monitoring programs could not provide data appropriate to immediate project evaluation, water quality characterizations or baseline data were developed that may be useful in future evaluations of long-term project impacts. Through close coordination with strong state and/or federal nonpoint source programs a few projects developed effective, well-designed water quality monitoring that should provide for project impact assessment in the relatively near future.

Despite these efforts, direct assessment of project-level impacts through water quality monitoring during the projects' 5-year time period was probably not feasible given the late start on monitoring in many projects, the absence of close coordination between implementation of treatment and the design of monitoring, the time needed to implement many practices, and the response time of natural systems. While many progress reports claimed significant impacts on water quality for the projects, such statements were rarely supported by solid monitoring data.

The most obvious cause of this was the short project period; many projects correctly stated that five years was too short a time to demonstrate water quality improvements. Major difficulties also stemmed from the failure to give water quality monitoring and evaluation adequate priority at the program level when project plans were formulated. As a consequence, many of the monitoring activities that were undertaken or adapted from other, ongoing programs had goals and capabilities poorly suited to project operation and evaluation. Monitoring was not well integrated into total project management and operation.

Monitoring efforts in many of the Assessment projects suffered from technical limitations in design and execution, including insufficient resources for operation, analysis, and interpretation; lack of specific focus on the project area or land treatment program; and lack of control for spatial and temporal variability. Furthermore, some project areas were poorly suited for successful demonstration of water quality response to land treatment in a realistic time frame due to excessive size, hydrologic lag time, or relatively small contribution to the overall water quality impairment. Because of these factors, monitoring programs in most of the Assessment projects were incapable of detecting or documenting water quality change. These shortcomings were often compounded by lack of early emphasis on land treatment tracking, collection of agricultural management data, and documentation of actual levels of agrichemical use. Even if water quality change had been detected, it would have been difficult to effectively attribute that change to the land treatment program.

Some of the Assessment projects were, however, successful in using water quality monitoring to: 1) document the effectiveness of specific management practices or demonstration sites; 2) establish a baseline water quality data set potentially useful in documenting future changes in water quality; or 3) initiating well-designed long-term monitoring efforts that can detect response to treatment. A few of the projects (CA, NC, UT, TX) were able to provide evidence of project impact on water quality through monitoring.

Summary of findings:

- Most projects engaged in monitoring by attempting to adapt external ongoing programs conducted by federal, regional, or state agencies to help evaluate project impacts.

- A few projects (MD, NC, WI, MI) were able to instigate effective water quality monitoring programs focused specifically on project evaluation, including both site level and watershed monitoring.

- Water quality monitoring training sponsored by the Assessment enhanced project staff abilities to plan and implement future water quality monitoring networks to assist land treatment projects and to effectively collaborate with monitoring agencies.

- DPs were typically better able to evaluate impacts of specific practices at demonstration sites through monitoring, while HUAs were usually better suited to watershed-scale monitoring.

- Many projects successfully conducted practice or demonstration site monitoring which established the effectiveness of the conservation practice(s) on improving or protecting water quality. The utility of this approach in project impact assessment is limited by the difficulty of showing watershed or receiving water response to land treatment programs and is highly dependent on the extent of adoption of the evaluated practice(s) in the project area. When the practices evaluated were not widely adopted, the evaluations were of little utility in project impact assessment, but may be important in promoting new practices for future adoption.

- Watershed-scale monitoring, especially associated with ongoing state and regional programs, was rarely successful in evaluating project impacts, either because the monitoring was not specifically designed to evaluate the project or because the hydrologic system was not conducive to respond to project changes within the short five year time frame. In several cases (AL, DE, OR, TX, UT), however, such monitoring was able to provide a baseline data set potentially useful in documenting future water quality changes.

- A few of the Assessment projects (MD, MI, NC, WI) were able to initiate well-designed water quality monitoring efforts specifically designed to evaluate project impacts. Most of these resulted from bringing the project into a strong state or federal nonpoint source evaluation program as a case study watershed, rather than simply trying to use ongoing data collection for evaluation.

- Even with well-designed water quality monitoring in hydrologically favorable areas, the five year DP and HUA program was too short to expect to document water quality change at the watershed level in response to land treatment. For the present Assessment projects with ongoing monitoring, recognizing long term water quality changes and incorporating their significance into USDA program consideration will be a challenge after the land treatment programs are concluded.

- The few strong water quality monitoring efforts that were initiated among the Assessment projects resulted from either the existence of a strong state nonpoint source program or a high level of communication and cooperation between land treatment and water quality personnel, or both. Such conditions favored the integration of land treatment and monitoring programs that is essential to effective evaluation of project impacts through water quality monitoring.

Recommendations:

- To be used effectively in evaluation of land treatment project impacts, water quality monitoring must focus specifically on the project area and be designed into the project from the start and integrated into the mainstream of the project.

- USDA-NRCS should continue to train staff in water quality monitoring concerns in order to promote close coordination and effective interaction with water quality monitoring agencies.

- Practice or demonstration site monitoring may be necessary to document practice effectiveness or to promote producer adoption; such monitoring should focus on practices actually used in the project. While practice monitoring can be important in suggesting what water quality variables are likely to respond to the land treatment program, it should be considered an indirect measure of overall project impact because the link between implementation of individual practices and watershed-level response depends on many factors in addition to the effectiveness of the practices.

- Whether adapted from external programs or conducted specifically for the project, water quality monitoring data should be presented, evaluated, and discussed in project reports. Failure to do so leaves report audiences ignorant of the status of the impaired water bodies and eliminates feedback loops between land treatment and water quality efforts that could improve targeting of land treatment, as well as project management and operation.

- To evaluate project impacts on water quality, project periods must be realistic. Five years is likely to be inadequate to document water quality response to land treatment on a watershed-scale.

- While land treatment implementation may be accomplished relatively rapidly, some provision for continued assessment of project impacts on water quality should be considered, especially when a sophisticated monitoring and evaluation program is initiated. When assessment results are expected long after the completion of the land treatment program, some mechanism of tracking projects and incorporating understanding of their ultimate impacts into agency program knowledge must be developed.

- When direct evaluation of project impacts on water quality is an important goal, future land treatment projects should be located in hydrologically favorable areas and in areas where the relationship between source areas and impaired water bodies is known. Areas with extremely long ground water travel times, where the project area contributes only a small proportion of the water or pollutant load or where pollutant movement pathways are poorly understood, for example, should be avoided because the probability of successful documentation of water quality response to land treatment is very small.

- Selection criteria for land treatment/water quality projects in which evaluation of water quality effects will be pursued should include consideration of state/federal nonpoint source programs already in place and favor locations where a strong state or federal program makes cooperation in water quality monitoring and evaluation more likely. The strongest monitoring efforts among the Assessment projects were those in states with active nonpoint source monitoring and evaluation programs.

- Even simple, inexpensive water quality monitoring can be valuable in project impact assessment. Rudimentary above/below monitoring, for example, conducted by land treatment personnel has a number of benefits. It can suggest the effectiveness of installed practices on in-stream water quality. It documents what water quality variables may respond to the treatment program and should therefore be monitored at a watershed outlet to document overall program effects. It can provide convincing evidence useful in enhancing producer and public acceptance of improved management. Finally, by involving land treatment personnel directly in monitoring and evaluation, it established a vital feedback loop between land treatment and water quality.

- Assessment of land treatment project impacts on water quality through monitoring should be an important component of future USDA land treatment programs. Clear documentation of water quality response to improved management practices at the project level should be a major goal. However, full documentation does not need to be pursued on every USDA land treatment project. A few carefully designed projects should be selected for full evaluation effort, in partnership with water quality monitoring agencies, both state and federal.

In other land treatment projects, evaluation could be based on land treatment tracking and documented changes in agrichemical application and management as secondary indicators of impact. Opportunities to integrate water quality monitoring and simulation models for project evaluation should continue to be explored.

4.0 SUMMARY AND RECOMMENDATIONS

A case-study group of 8 Demonstration Projects and 8 Hydrologic Unit Area Projects encompassing a wide range of geographic setting, agriculture type, and water quality problem was used to document the extent to which USDA ET&FA projects made progress in improving or protecting water quality by reducing agricultural nonpoint source pollutants. Progress was evaluated through three indicators:

- Producer adoption of conservation practices and agricultural management changes
- Project staff competency in use of models to simulate reductions in sediment, nutrient, and pesticide losses from the edge-of-field or bottom-of-root zone
- Monitored change in water quality in impaired or threatened water bodies

The project team conducted the Assessment from 1991-1995 through site visits, analysis of project annual reports, development of a computerized land treatment data base, and a variety of workshops and meetings.

There was substantial adoption of conservation practices and improved management among the case-study projects, including 66 different practices with national standards and another 68 practices, including some with State-approved components of nationally defined practices as well as new or innovative practices that were demonstrated in the DPs. The most widely adopted national practices included nutrient management, irrigation water management, conservation cropping, cover/green manure crop, conservation tillage, pesticide management, and animal waste utilization. Most of the projects initially lacked formal, detailed land treatment tracking or agricultural management monitoring. However, by FY 1994 all projects were doing an adequate job of tracking basic land treatment information and several projects undertook more intensive efforts to track actual management changes, including use of a GIS to spatially reference these changes.

The projects reported substantial improvements in agrichemical use by combining practice implementation tracking with nutrient and pesticide use data reported by producers. Estimated reductions in nitrogen applications ranged from 14 to 129 pounds/acre; reductions in phosphorus ranged from 3 to 106 pounds/acre. Total annual reductions compared to pre-project baseline, as of FY 1994 were a reported 22.3 million pounds of nitrogen and 10.3 million pounds of phosphorus.

Assessment of overall change in pesticide applications was more complex because changes involved timing, formulation, and method, not only rates of application; however, several projects reported significant improvements in pest management and more effective targeting of pesticide management practices to problem soils.

Project staff in several projects raised capabilities to use very complex physical process simulation models to project changes in pollutant losses from agricultural land due to changes in conservation practices and agrichemical management. Eight projects used a first-level screening tool such as NPURG to help target treatments to vulnerable areas. While few individuals among project staffs had experience with complex physical process simulation models at project initiation, six project annual reports showed that staff had acquired a high degree of competence in field-scale model calibration, clear documentation of modeled results, and proper and logical discussion of results in terms of the water quality objectives of their project. Field-scale model use in the remaining ten project reports was poorly documented or not reported. The field-scale model used most frequently was EPIC. Only three projects demonstrated clear skill in using watershed-scale models; AGNPS was the most widely used watershed-scale model.

Water quality monitoring was not designed specifically into any of the projects, but most did engage in some form of monitoring, generally added after project inception. Direct assessment of project-level impacts through water quality monitoring during the projects' lifetime was probably not feasible given the late start on monitoring in many projects, the absence of close coordination between implementation of treatment and the design of monitoring, inadequate monitoring design and/or resources, the time needed to implement many practices, lack of control for spatial and temporal variability, and the long response time of natural systems. Major difficulties also stemmed from the failure to give water quality monitoring and evaluation adequate priority at the program level when project plans were formulated. As a consequence, many of the monitoring activities that were undertaken or adapted from external ongoing programs had goals and capabilities poorly suited to project operation and evaluation. Monitoring was not well integrated into total project management and operation. The five-year project duration was in any case inadequate to document water quality response to treatment through monitoring.
Many of the Assessment projects were, however, successful in using water quality monitoring to: 1) document the effectiveness of specific management practices or demonstration sites; 2) establish a baseline water quality data set potentially useful in documenting <u>future</u> changes in water quality; or 3) initiating well-designed long-term monitoring efforts that can detect response to treatment. A few of the projects (CA, NC, TX, UT) were able to provide evidence of project impact on water quality through monitoring.

Recommendations:

- USDA should continue to emphasize the need for project planners to establish well-documented, clear, and quantifiable objectives for land treatment/water quality projects.

- Selection criteria for land treatment/water quality projects should include consideration of state/federal nonpoint source programs already in place and favor locations where strong state or federal programs make cooperation in water quality monitoring and evaluation more likely. The strongest monitoring efforts among the Assessment projects were those in states with active nonpoint source monitoring and evaluation programs.

- Future land treatment/water quality projects should be located in hydrologically favorable areas and in areas where the relationship between source areas and impaired water bodies is known. Areas with extremely long ground water travel times, where the project area contributes only a small proportion of the water or pollutant load or where pollutant movement pathways are poorly understood, for example, should be avoided because the probability of successful documentation of water quality response to land treatment is very small.

- A systematic, objective, and credible means of targeting treatment to critical problem areas is needed in all water quality projects. Such a system should use local staff knowledge and expertise as a starting point, quantitative screening tools and physical process simulation models if skilled model expertise is available, and land or water based data collection to identify and prioritize pollution source areas and activities.

- To be used effectively in evaluation of land treatment project impacts, water quality monitoring must focus specifically on the project area and be designed into the project from the start. Integration of monitoring into the project mainstream can foster important feedback loops between land treatment and monitoring efforts that can improve targeting of land treatment, as well as overall project management and operation.

- Future land treatment/water quality programs should incorporate guidance on specific performance measures and use of these measures to evaluate project effectiveness.

- All land treatment/water quality projects should establish quantitative goals for land treatment implementation, based on best available estimates of management improvements required to protect or improve water quality in the identified receiving bodies.

- A practice implementation accounting system is needed that, to the extent possible, records all practice implementation in the project area, regardless of annual vs. multi-year, presence or absence of technical assistance, demonstration vs. non-demonstration site, in order to measure actual, on-the-ground progress toward project land treatment goals that may affect water quality.

- Land treatment tracking is critical and should include not only basic accounting of implementation but also spatial dimensions - where the treatment was applied on the landscape. Spatial referencing with respect to ground or surface water bodies and to paths of pollutant transmission is key to evaluating project impacts on water quality.

- Future programs to assess water quality changes resulting from land treatment programs should be designed at the outset to incorporate monitoring and be carefully selected to provide an adequate evaluation design.

- USDA agencies should continue to place high priority on the development of and training in the use of analytical screening tools for nutrient and pesticide leaching and runoff and sediment production to assist in identifying potential pollutant source areas and areas to target management improvements.

- USDA agencies should continue to emphasize development of staff capabilities to chooseappropriate simulation models, both field-scale and watershed-scale, acquire reliable input data at least cost, and use selected models properly, including output interpretation and sensitivity analysis. Given the significant time required for an individual to become able to quickly and effectively use models in project planning and in simulation of future water quality effects, agencies should focus training on a cadre of individuals who could assist multiple projects.

- USDA agencies should continue to train staff in key water quality monitoring concepts in order to promote close coordination and effective interaction with water quality monitoring capabilities of other federal and state partners.

- Assessment of land treatment project impacts on water quality through monitoring should be an important component of future USDA-sponsored land treatment/water quality programs. Clear documentation of water quality response to improved management practices at the project level should be a major goal. However, full documentation does not need to be pursued on every project. A few carefully designed projects should be selected for full project evaluation effort, in partnership with water quality monitoring agencies, both state and federal. In other projects, evaluation could be based on land treatment tracking and documented changes in agrichemical application and management as secondary indicators of impact.

- Even simple, inexpensive water quality monitoring can be valuable in project impact assessment. Rudimentary monitoring comparing water quality upstream and downstream of a practice, for example, has a number of potential benefits. It can suggest the effectiveness of installed practices on in-stream water quality. It documents what water quality variables may respond to the treatment program and should therefore be monitored at a watershed outlet to document overall program effects. It can provide evidence useful in enhancing producer and public acceptance of improved management. Finally, by involving land treatment personnel directly in monitoring and evaluation, it can establish vital cooperation, information sharing, and feedback between land treatment and water quality activities.

- Monitoring of water quality at a practice or site may be necessary to document practice effectiveness, to predict what water quality variables are likely to respond to the land treatment program, or to promote producer adoption and should focus on practices actually used in the project. Such monitoring should, however, be considered an indirect measure of overall project impact because the link between implementation of individual practices and watershed-level response depends on many factors in addition to the effectiveness of individual practices.

- To evaluate project impacts on water quality, project duration must be realistic. Five years is likely to be inadequate to document water quality response to land treatment on a watershed-scale. Evaluation periods at the watershed-scale should be tied to the likely response time of the natural system.

- Opportunities to integrate water quality monitoring and simulation models for project planning and evaluation should continue to be explored. Modeling can project changes that are difficult, costly, or time-consuming to monitor. During project operation as well as during planning, appropriate modeling permits comparative estimation of pollutant loadings under different project scenarios. Monitoring can provide data essential for model validation and can address water quality dimensions not handled by currently available models.

- While adoption of conservation practices and management changes may be accomplished relatively rapidly, some provision for continued assessment of project impacts on water quality should be considered, especially when a sophisticated monitoring and evaluation program is initiated. When assessment results are expected long after the completion of the land treatment program, some mechanism of tracking projects and incorporating understanding of their ultimate impacts into agency program knowledge must be developed.

Appendix A

Descriptions of Water Quality Projects Participating in this Assessment

Anoka Sand Plain Demonstration Project
Minnesota

This project is located in a region characterized by sandy soils that are low in organic matter and that overlie a shallow aquifer. some 330,000 acres of crops are grown under both irrigated and non-irrigated conditions. Dairy and poultry are the main livestock production activities.

Some 70,000 acres are irrigated. Most producers apply nitrogen at planting or as a sidedress during the summer. Few use a nitrification inhibitor. Over four-fifths use herbicides, and most use crop rotations for weed control. Nearly three-fourths of the irrigators either do not practice scheduling or use the "hand-feel" method. Animal waste management is an integral component of all nutrient management plans where producers apply animal waste to cropland fields ICM is being demonstrated on 40 farms.

Nitrate concentrations exceeding 10 milligrams/liter have been documented in 30% of wells tested, with the highest levels in areas of intense irrigated crop production. There is also an incidence of triazine herbicide detections in area groundwater. Because the Anoka aquifer is believed to recharge the Mississippi River and another aquifer to the south, water quality problems in the project area may be a threat to the drinking water supply for Minneapolis-St. Paul.

East Sidney Lake Watershed HUA
New York

East Sidney Lake is a reservoir created in 1950 for flood control and subsequently opened for recreation. Significant groundwater resources occur only in the floodplain soils of Ouleout Creek. East Sidney Lake has been highly eutrophic since its inception. Lake water quality is impaired for swimming and stressed from an aesthetic standpoint as a result of sediment, nutrients, and oxygen-demanding substances from the watershed. Oxygen depletion in the deeper lake waters is common. In some areas, private wells have been contaminated with nitrate and bacteria.

There are 138 agricultural operations in the 70,800-acre watershed. Corn and hay are the principal crops grown, primarily in support of the 52 dairy operations. Tillage is predominantly conventional. Nutrient application methods are generally those designed to maximize crop production for livestock operations.

Because storage facilities are limited animal waste is normally spread daily except in the winter, when it is stacked on the ground. The primary agricultural pollution causes are: barnyard runoff, overgrazing, poor manure management, improper manure storage, and livestock in streams. Principal pollutants are phosphorus and microorganisms such as *Giardia lamblia.*

Herrings Marsh Run Demonstration Project
North Carolina

This 5,100-acre project is in southeastern North Carolina. Soils are medium to coarse in texture and are subject to seasonally high water tables. Surface waters have been designated as "support threatened" because of biological oxygen demand (BOD), nutrient, and sediment inputs from agricultural nonpoint sources. Groundwater quality is also threatened by nitrogen and pesticides.

This project is marked by intensive agricultural activity, including major poultry and swine operations. In terms of acreage, major crops are corn, soybeans, vegetables, tobacco, and cotton. Tillage is largely conventional. Nutrient and pesticide application rates and methods are based on tradition. Nutrients, particularly nitrogen, are the primary nonpoint source pollutants. Animal manure provides more than half of the nitrogen needed for crop production, yet 90% of crop nutrients are purchased in the form of mineral fertilizers. Dead poultry disposal is also a major concern. More than 50 different pesticides were in use at the time of project inception. Animal waste lagoons are typically not built to current SCS standards and may not be properly managed. Many are undersized and subject to overflow.

Illinois River Sands HUA
Illinois

The 250,000-acre project area is level to moderately sloping with well drained sandy soils underlain by an extensive sand and gravel aquifer that lies 3 to 12 feet below the surface. This shallow aquifer is the main rural drinking water source. Some 450 farms produce corn, soybeans, and vegetables. Center pivot irrigation is extensive. A few specialty crops require pesticide application every 3-4 days through the growing season. Although impairment of the groundwater has not yet been documented, detection of high concentrations of nitrate and trace levels of pesticides in shallow groundwater in a 1986-87 survey sounded a warning of significant threats to drinking water quality.

Inland Bays HUA
Delaware

This 157,000-acre HUA includes three basins in southeast Delaware: Rehoboth Bay, Indian River Bay, and Little Assawoman Bay. Topography is very gently sloping. Dominant soils are sandy and well drained to excessively well drained. Most streamflow derives from baseflow; less than 10% annual precipitation flows into the Bays as surface runoff. Over 75% of nutrient loads entering the Bays are believed to be transported in baseflow.

Agriculture is dominated by livestock production, particularly poultry, but also hog, beef, and dairy operations. Cropland, mainly corn and soybeans, occupies about 40% of the HUA. Two-thirds of corn acreage receives nearly 300 lbs/ac of nitrogen. Atrazine, metolachlor, and alachlor are the primary pesticides used. The rapid growth of the poultry industry has created problems for storage and utilization of poultry manure and for dead bird disposal.

Agriculture supplies 35-55% of the annual nitrogen load to the bays. Use of nitrogen fertilizers and spreading of poultry manure in excess of crop needs on sandy soils are the major sources of nitrate loading to groundwater. Another source is concentrated animal housing. All three bays have excessive levels of nitrogen during most of the year. Low dissolved oxygen levels, high bacteria counts, and high nitrate levels are contribute to impairment of fish populations, shellfishing, and recreation. Nitrate contamination of groundwater is serious; one-third of all wells tested had nitrate exceeding drinking water limits.

Lake Manatee Demonstration Project
Florida

Lake Manatee provides drinking water for Bradenton and nearby communities on Florida's central Gulf Coast. The lake is highly eutrophic with algae blooms being common. Because the upper reaches of the lake's 88,000 hectare watershed lie in a phosphate mining region, phosphorus levels in lake water are very high (>200 μg/l) and the lake is considered to be primarily nitrogen limited. High levels of nitrate have been documented in shallow groundwater and drainage waters from traditionally-managed citrus and vegetables. These elevated nitrate levels are thought to result from excessive application of nitrogen fertilizers (300 - 400 lbs/ac on vegetables is typical) and poor irrigation water management. Nitrates and pesticides are transported in shallow baseflow to the lake.

Little Bear River HUA
Utah

Agriculture within this 197,000-acre project is devoted primarily to livestock feed production, grazing, and wildlife. Predominant land uses are rangeland (70%), irrigated cropland (20%), and dry cropland (5%). Major crops are small grains and alfalfa. Tillage systems are conventional. Very few waste storage facilities exist; manure is spread all year long except during the winter when it is stacked on the ground. Application rates vary from 2 to 20 tons/acre. Little manure is incorporated in the soil when crop planting begins.

The Little Bear River watershed is a major source of pollutants to Hyrum and Cutler Reservoirs and to the Bear River. Pollutants, their sources and the methods of transport include: sediment from streambank and channel erosion; nutrients and coliform bacteria from pasture, cropland, and feedlots; irrigation return flows; and phosphorus from rangeland during spring snowmelt runoff. Currently, known water quality problems are mainly related to surface water.

The Little Bear River has shown violations of Utah water quality standards since 1984/1985 for phosphorus, nitrogen, BOD, dissolved oxygen (DO), and bacteria. Poor water quality due to eutrophication has impaired fisheries and recreational values in Hyrum and Cutler Reservoirs.

Mid-Nebraska Water Quality Demonstration Project
Nebraska

Soils in this irrigated corn region of south-central Nebraska uplands are generally medium to fine textured loess soils that overlie groundwater 100-300 feet deep. Typical nitrogen application on corn is 180 lbs/ac. Three-fourths of all irrigation on the 33 demonstration farms is by furrow, the remainder by center pivots. About half of the cooperators apply nitrogen in the fall, regularly use crop consultants, and use banded herbicides.

Based on well testing, groundwater has shown trends of increasing nitrate and atrazine levels. High nitrate levels correspond to irrigated corn areas. While impairment of the deep aquifer has not been observed, continued deep percolation of excess irrigation water is expected to drive nitrates and possibly pesticides in the vadose zone downward into the aquifer.

Monocacy River Watershed Demonstration Project
Maryland

Over 65% of this central Maryland watershed is in agricultural use, primarily cropland. There are some 3,500 farms in the watershed; livestock operations dominate, including dairy, poultry, and hogs. Surface waters are impaired for aesthetics, recreation, fisheries, and commercial uses by nonpoint sources. Principal pollutants are sediment and nutrients from a combination of inorganic fertilizers and animal wastes. Groundwater in shallow limestone aquifers is threatened by pesticides and nitrates from agricultural chemicals and fertilizers.

Ontario HUA
Oregon

Intensive irrigated agriculture is practices in the semi-arid valleys of eastern Oregon. Major crops, in terms of acres cultivated, are wheat, sugar beets, onions, potatoes, dry beans, field corn, sweet corn, and mint. Ninety percent of the cropland is furrow irrigated; 200-400 lbs/ac of nitrogen are common. Dacthal (used only on onions) is the pesticide of main concern. It is banded at 4 lbs/ac or broadcast at 6-9 lbs/ac.

Drinking water is impaired by high concentrations of nitrate nitrogen, with levels exceeding 10 mg/l EPA (drinking water standard) in 30% of wells tested. Sodium, arsenic, selenium, and lead (all of which occur naturally in the watershed) have been detected at concentrations exceeding EPA's Maximum Contaminant Levels in groundwater. Dacthal has been detected in some groundwater samples, but well below critical health levels. Irrigation and widespread fertilizer and pesticide use are believed to be the major contributors to groundwater quality problems. High levels of sediment and nutrients in surface waters result from furrow irrigation.

Rice Pesticide Demonstration Project
California

Rice agriculture is the only economically viable crop on the poorly drained clay soils of this Sacramento Valley project. The predominant irrigation method is continuous flooding from sowing to harvest. Water flows from one field to another, and excess water enters a drain at the end of the field, where it may be recycled, reused in a downstream field, or discharged to the river.

The water quality problem is pesticide residue released to surface waters during rice irrigation. The pesticides of concern are Molinate and Bensulfuron. Conventional systems which release used irrigation water directly into surface waters allow pesticide residues into agricultural drains and waterways, killing fish and impairing drinking water supplies.

Pesticide levels in public waters have been reduced over 90% since 1983. The primary means of reducing residual pesticide levels in rice irrigation has include holding or irrigation tailwater on the rice field or on set-aside lands to allow natural degradation to occur. Future State water quality standards mandate ever-decreasing pesticide concentrations, and the decreasing availability of idle acreage for water holding serves as an incentive for producers to adopt the improved irrigation tailwater practices demonstrated in the project.

Sand Mountain-Lake Guntersville HUA
Alabama

This 400,000-acre HUA in northeast Alabama includes the Lake Guntersville Reservoir, the major source of water-based recreation in the area. Agriculture is composed of small livestock operations, primarily poultry and hogs; one-third of the project area is in corn, soybeans, and potatoes. Poultry operators spread 6-15 tons of litter annually (usually in one spring application) for average application rates of 345 lbs/ac for nitrogen and 470 lbs/ac for phosphorus. Most (90 percent) swine lagoons overflow during the wet season. Spreading lagoon waste is not common as it is relatively labor intensive for the amount of nutrients applied. Some 75 percent of the HUA's cropland erodes above "acceptable levels", two-thirds of the cropland is tilled under systems that leave more than 15% residue. Many uses of Lake Guntersville, including public water supply, recreation, fisheries, and aesthetics are impaired by sediment, nutrients, and bacteria.

Groundwater contamination may also be a problem. Bacterial contamination has been recorded in a high percentage of area wells and much of the HUA has a high potential for nitrate leaching.

Seco Creek Demonstration Project
Texas

This predominantly rangeland watershed of 170,000 acres overlies the Edwards Aquifer, the sole source of water supply for San Antonio. In the recharge area, land use is predominantly rangeland (150,000 acres). Beyond the recharge area is 16,000 acres of cropland of which 2,600 acres is irrigated. In many cases, streams enter the aquifer through open caves in the karst recharge zone, providing no filtration for surface waters.

In the upper reaches of the watershed, runoff flows into Seco Creek, which flows until it reaches the recharge area and then enters the aquifer. Below this recharge zone, however, there is no flowing stream except during occasional extreme high flow events when the creek flows once more to recharge downstream reservoirs. Because surface waters can move directly into the Edwards Aquifer, the potential for polluting this aquifer with agricultural runoff and sediment is considered sizable. Groundwater is currently suitable for most purposes.

Sycamore Creek Watershed HUA
Michigan

This project includes some 68,000 acres of primarily agricultural land in south-central Michigan. Agriculture is predominantly livestock based, including dairy, hogs, and beef. Sources of nonpoint source pollutants include severe erosion and over-application of fertilizers and pesticides. Corn, soybeans, and wheat are the principal crops cultivated. Tillage is primarily conventional. Water quality is significantly affected by sedimentation and oxygen depletion, which impair the suitability of the stream for recreation and for fish habitat. Violations of Michigan water quality standards for dissolved oxygen have been recorded. High nutrient concentrations contribute to eutrophication and threaten groundwater quality.

Upper Tippecanoe River Watershed HUA
Indiana

This 209,000-acre project in northeastern Indiana is underlain by outwash deposits of sand and gravel, which form the principal aquifer along the Tippecanoe River. High well yields, high permeability, and shallow water tables are characteristic of the area. There are 217 natural lakes and impoundments in the area. About 75% of the watershed is devoted to agriculture, dominated by swine and poultry. The main crops are corn, soybeans, wheat, and hay. Tillage is 80 percent conventional. Fertilizer is normally broadcast in fall or spring before planting. Nearly all animal waste is broadcast spread. Because most facilities have a 90-day or less storage capacity, manure is spread 2-3 times annually, often on the same fields. Rates of 10-20 tons/acre are common.

One-third of the watershed is a major erosion problem area. Sediment and associated nutrients are significant contributors to lakes eutrophication. Pesticide leaching and runoff potentials are high for one-half and one-fourth, respectively, of the HUA's soils. Sampling of private wells from 1984 through 1987 showed that 40% to 55% of the wells contained nitrate levels exceeding 10 mg/l.

Watershed Demonstration Project - East River
Wisconsin

Nutrients, pesticides, and toxics from agriculture are contributing to groundwater and surface water contamination in this 141,000-acre watershed. Nearly a quarter of the watershed lies in metropolitan Green Bay. Agriculture is dominated by 400 dairy operations with some 42,000 animal units. Major crop rotations are typically 2 years of corn, followed by small grains, and 2-4 years of hay. Tillage is 82 percent conventional. Most farmers have only a minimal manure management program, apply excessive amounts of nitrogen and phosphorus, and do not scout for pests. A typical phosphorus application rate is 120 lbs/ac, of which 30 percent is from inorganic fertilizer and 70 percent from manure. A typical nitrogen application rate is 220 lbs/ac, of which 25 percent is from inorganic fertilizer, 40 percent from manure, and the remainder from legumes such as alfalfa. Pesticide application methods and rates are extremely variable from producer to producer. Major reaches of the East River flow over fractured limestone (karst) and rapidly recharge shallow aquifers used by the rural population. Some 30% of watershed soils have high groundwater pollution potential. High nitrate, pesticide, petroleum, and VOC levels have been documented in shallow private wells, and there is some evidence suggesting leakage to deeper regional aquifers. Surface water problems are important. Problems with excessive sediment, phosphorus, and toxics from agriculture have caused high turbidities, algal blooms, and fish consumption advisories. Since the project was initiated, priorities have shifted away from groundwater quality to phosphorus and sediment loading to the surface waters of nearby Green Bay.

APPENDIX B-1

Project-Assisted Adoption of Practices, FY 1990-1994

Demonstration Projects

Project	Practice #*	Practice Name	Adopted** Demo sites	Non-demo	Total	Units
TX	645	Wildlife upland habitat management	129330		129330	acre
TX	642	Well	4		4	number
TX	638	Water & sediment control basin	12		12	number
NC	633	Waste Utilization	252		252	acre
MN	633	Waste utilization	1977		1977	acre
MD	633	Waste utilization	34809		34809	acre
WI	633	Waste utilization	23370		23370	acre
WI	595	Pest management	13602		13602	acre
FL	595	Pest management	521	9873	10394	acre
NE	595	Pest management		44896	44896	acre
TX	595	Pest management	250		250	acre
MN	595	Pest management	13775		13775	acre
NC	595	Pest management	728		728	acre
NE	590	Nutrient management	166717	44144	210861	acre
TX	590	Nutrient management	5637		5637	acre
WI	590	Nutrient management	13364	10983	24347	acre
FL	590	Nutrient management	521	4996	5517	acre
MD	590	Nutrient management	49932	7926	57858	acre
MN	590	Nutrient management	20358		20358	acre
NC	590	Nutrient management	1460		1460	acre
CA	587	Water control structure		826	826	number
MD	585	Stripcropping	1997		1997	acre
TX	574	Spring development	3		3	number
MD	574	Spring development	45		45	number
MD	558	Roof runoff management	4		4	number
FL	557	Row arrangement		482	482	acre
FL	556	Planned grazing system		4246	4246	acre
TX	556	Planned grazing system	103945		103945	acre
TX	548	Grazing land mechanical treatment	30		30	acre
CA	533	Pumping plant for water control		1	1	number
TX	528	Proper grazing use	125517		125517	acre
FL	528	Proper grazing use		1073	1073	acre
FL	512	Pasture/hayland planting		44	44	acre
MD	512	Pasture/hayland planting	497		497	acre
TX	510	Pasture/hayland management	2784		2784	acre
MD	510	Pasture/hayland management	3398		3398	acre
FL	510	Pasture/hayland management		810	810	acre
FL	484	Mulching		179	179	acre
TX	472	Livestock exclusion	283		283	acre
NE	464	Irrigation land leveling		163	163	acre
CA	464	Irrigation land leveling		560	560	acre
FL	449	Irrigation water management		8286	8286	acre
TX	449	Irrigation water management	4550		4550	acre
NE	449	Irrigation water management	166717	124853	291570	acre
MN	449	Irrigation water management	7701		7701	acre
FL	449	Water table managment	822		822	acre
CA	447	Irrigation system-tailwater recovery		43	43	number
NE	447	Irrigation system-tailwater recovery	9	229	238	number
WI	425	Waste storage pond	11		11	number

APPENDIX B-1(Continuation)

Demonstration Projects

Project	Practice #*	Practice Name	Adopted** Demo sites	Non-demo	Total	Units
NE	425	Waste Storage Pond		3	3	number
MD	412	Grassed Waterway	34		34	acre
FL	412	Grassed Waterway		1	1	acre
NE	412	Grassed Waterway		10	10	acre
TX	393	Filter strip	110		110	acre
FL	393	Filter strip		2	2	acre
CA	388	Irrigation field ditch		92307	92307	feet
TX	382	Fencing	145964		145964	feet
MD	362	Diversion/terrace	2075		2075	feet
TX	352	Deferred grazing	70576		70576	acre
MD	344	Crop residue use	8277		8277	acre
TX	344	Crop residue use	10951		10951	acre
FL	344	Crop residue use		482	482	acre
MD	342	Critical area planting	77		77	acre
MD	340	Cover and green manure crop	6230		6230	acre
FL	340	Cover and green manure crop	729	86462	87191	acre
MN	340	Cover and green manure crop	1073		1073	acre
TX	338	Prescribed burning	6198		6198	acre
MD	330	Contour farming	818		818	acre
WI	329	Conservation tillage	142		142	acre
MD	329	Conservation tillage	14558		14558	acre
NE	328	Conservation cropping sequence		705	705	acre
MD	328	Conservation cropping sequence	17640		17640	acre
NC	328	Conservation cropping sequence	311		311	acre
WI	328	Conservation cropping sequence	1954		1954	acre
TX	328	Conservation cropping sequence	11704		11704	acre
MN	324	Chiseling & subsoiling	313		313	acre
FL	314	Brush management		644	644	acre
TX	314	Brush management	7221		7221	acre
MD	313	Waste storage structure	19		19	number
WI	313	Waste storage structure	6		6	number
WI	312	Waste management system	7		7	number
WI		Integrated crop management		20300	20300	acre
MN		Animal waste managed	61175		61175	tons
TX		Rangeland treated		78494	78494	acre
TX		Pasture & hayland treated		3208	3208	acre
TX		Cropland treated		13747	13747	acre
MN		Soil moisture monitoring	217		217	number
TX		Well sealing	1		1	number
NE		Flow Meters	37		37	number
MN		Irrigation system efficiency	10		10	number
MN		Integrated Pest Management plan	7111		7111	acre
CA		Flow meter		4	4	number
MN		Manure analysis	95		95	number
WI		Manure analysis	163		163	number
MN		Vadose/groundwater sampling for N	1823		1823	number
NE		Vadose/groundwater sampling for N	8		8	number
MN		Root zone sampling for N	933		933	number
TX		Root zone sampling for N	5		5	number

APPENDIX B-1 (Continuation)

Demonstration Projects

Project	Practice #*	Practice Name	Adopted** Demo sites	Non-demo	Total	Units
MN		Irrigation water tests for N	173		173	number
MN		Nutrient mnagement plan	11232		11632	acre
MN		Use of N meters	933		933	number
MN		N quick test	1073		1073	number
MN		Manure spreader calibration	20		20	number
WI		Milkhouse waste disposal	3		3	number
MN		Improved irrigation efficiency-cropland	1520		1520	acre
TX		Improved irrigation efficiency-cropland	735		735	acre
TX		Buffer strips	63		63	acre
TX		Stream corridor livestock exclusion	20		20	an. units
TX		Irrigation scheduling	1009		1009	acre
MN		Irrigation scheduling	7282		7282	acre
TX		Low energy precision application	385		385	acre
TX		Furrow diking	1410		1410	acre
TX		Surge irrigation	100		100	acre
NE		Surge Irrigation	1075	2160	3235	acre
FL		Microjet system improvement	11		11	acre
TX		Irrigation rates	100		100	acre
MN		Irrigation rates	1642		1642	acre
MN		Irrigation water timing/duration	5137		5137	acre
TX		Irrigation water timing/duration	654		654	acre
FL		Fully enclosed seeps	316	6114	6430	acre
FL		Water table monitoring floats	1138	16975	18113	acre
TX		Crop rotation for pest control	1210		1210	acre
MN		Crop rotation for pest control	4445		4445	acre
MN		Mechanical control of pests	4287		4287	acre
CA		Rice water holding period		22553	22553	acre
TX		Pesticide application/timing	984		984	acre
MN		Pesticide application/timing	4334		4334	acre
FL		Pesticide selection		200	200	acre
MN		Pesticide selection	6841		6841	acre
TX		Pest Scouting	1520		1520	acre
FL		Pest Scouting		48450	48450	acre
MN		Pest Scouting	6809		6809	acre
MD		Livestock stream crossing	3		3	number
TX		Rainwater storage	1116		1116	acre
FL		Double cropping	544	51700	52244	acre
MN		Alternative N formulations	3667		3667	acre
FL		Alternative N formulations	20	2400	2420	acre
MN		Use of N inhibitors	992		992	acre
MN		Banding of nutrients	6367		6367	acre
TX		Split application of N	2108		2108	acre
MN		Split application of N	8927		8927	acre
FL		Split application of N	1035	52400	53435	acre
MN		Nutrient credits for crops	4087		4087	acre
MN		Reduced yield goals	931		931	acre
FL		Tissue analysis	470	23500	23970	acre
MN		Tissue analysis	7599		7599	acre
TX		Tissue analysis	100		100	acre

APPENDIX B-1 (Continuation)

Demonstration Projects

Project	Practice #*	Practice Name	Adopted** Demo sites	Non-demo	Total	Units
MN		Fertilizer application and timing	7796		7796	acre
TX		Fertilizer application and timing	2331		2331	acre
FL		Soil testing	521		521	acre
MN		Soil testing	10534		10534	acre
TX		Soil testing	4872		4872	acre
MN		Waste applied-rates/time	1218		1218	acre
WI		Waste applied-rates/time	306			acre
FL		Cover Cropping	504	141100	141604	acre
WI		Plow-down animal waste	36		36	acre
MN		Plow-down animal waste	1223		1223	acre
WI		Knifing animal waste	202		202	acre
MN		Knifing animal waste	74		74	acre
MN		Composted waste disposal	120		120	acre
FL		Irrigation system, surface/subsurface	195	400	595	acre
NE		Irrigation system, surface/subsurface	2165		2165	acre
CA		Irrigation system, surface/subsurface		3288	3288	acre
NE		Irrigation system-sprinkler	1848	5115	6963	acre
FL		Irrigation system-trickle	350	15282	15632	acre
CA		Irrigation water conveyance-Low Pres.		34232	34232	feet
NE		Irrigation water conveyance-Low Pres.		399305	399305	feet
NE		Irrigation water conveyance-High Pres.		74752	74752	feet
FL		Irrigation water conveyance-High Pres.		2000	2000	feet
CA		Irrigation water conveyance-pipeline		3511	3511	feet

* NRCS practice #s are given to reference established practices for which national standards and specifications exist. Practices without NRCS numbers are innovative or regional practices for which national standards have not yet been established or are components of national practices.

** Demo sites were locations where project staff with the cooperation of the land owner installed and demonstrated the effectiveness of project practices. Non-demo areas were locations elsewhere with the DP area where operators adopted practices without project on-farm demonstration assistance.

APPENDIX B-2

Project-Assisted Adoption of Practices, FY 1990-1994

Hydrologic Unit Area Projects

Project	Practice #*	Practice Name	Adopted	Units
UT		Stream corridor livestock exclusion	150	an. units
IL	642	Well	413	number
UT	642	Well	2	number
IN	638	Water & sediment control basin	89	number
UT	633	Waste utilization	283	acre
IN	633	Waste utilization	10836	acre
MI	633	Waste utilization	2162	acre
OR	633	Waste utilization	1110	acre
NY**	633	Waste utilization	254	acre
AL	633	Waste utilization	58	acre
NY**	620	Underground outlet	537	feet
UT	614	Trough or tank	4	number
IN	612	Tree planting	341	acre
NY**	606	Subsurface drain	8378	feet
AL	600	Terrace	18500	feet
IN	595	Pest management	14787	acre
IL	595	Pest management	1223	acre
IL	590	Nutrient management	2241	acre
MI	590	Nutrient management	21702	acre
DE	590	Nutrient management	43502	acre
IN	590	Nutrient management	14149	acre
UT	590	Nutrient management	422	acre
NY**	590	Nutrient management	408	acre
AL	590	Nutrient management	19257	acre
OR	590	Nutrient management	23802	acre
UT	587	Water control structure	15	number
NY**	587	Water control structure	1	number
NY**	586	Stripcropping-field	70	acre
NY**	585	Stripcropping-contour	90	acre
UT	584	Stream channel stabilization	5450	feet
UT	582	Open channel	300	feet
UT	580	Streambank/shoreline protection	8575	feet
UT	580	Feedlot windbreak	1	acre
UT	574	Spring development	5	number
NY**	561	Heavy use area protection	5	acre
NY**	558	Roof runoff management	1	number
UT	556	Planned grazing system	3090	acre
NY**	556	Planned grazing system	114	acre
UT	550	Range seeding	459	acre
UT	533	Pumping plant for water control	1	number
UT	528	Proper grazing use	3955	acre

APPENDIX B-2 (Continuation)

Hydrologic Unit Area Projects

Project	Practice #*	Practice Name	Adopted	Units
UT	516	Pipeline	9041	feet
IN	512	Pasture/hayland planting	636	acre
OR	512	Pasture/hayland planting	110	acre
UT	512	Pasture/Hayland planting	50	acre
MI	512	Pasture/hayland planting	1865	acre
AL	512	Pasture/hayland planting	1015	acre
IN	510	Pasture/hayland management	1013	acre
UT	510	Pasture/hayland management	524	acre
OR	510	Pasture/hayland management	128	acre
NY**	510	Pasture/hayland management	54	acre
AL	510	Pasture/hayland management	15186	acre
OR	484	Mulching	1440	acre
UT	472	Livestock exclusion	128	acre
IL	472	Livestock exclusion	1736	acre
IN	468	Lined waterway/outlet	150	feet
UT	464	Irrigation land leveling	150	acre
OR	464	Irrigation land leveling	240	acre
UT	449	Irrigation water management	414	acre
OR	449	Irrigation water management	20855	acre
IL	449	Irrigation water management	1310	acre
OR	447	Tailwater recovery system	10	number
UT	442	Irrigation system-sprinkler	21	number
OR	439	Irrigation water conveyance, pipe	198000	feet
UT	430	Irrigation pipeline	29316	feet
UT	430	Irrigation water conveyance, high pressure	3080	feet
OR	428	Irrigation water conveyance, ditch	43630	feet
OR	425	Waste storage pond	4	number
IN	412	Grassed waterway	33	acre
IN	411	Grasses/legumes in rotation	428	acre
NY**	411	Grasses/legumes in rotation	84	acre
OR	411	Grasses/legumes in rotation	1213	acre
UT	410	Grade stabilization structure	13	number
IN	410	Grade stabilization structure	8	number
IN	393	Filter strip	10220	feet
OR	393	Filter strip	93	acre
UT	393	Filter strip	3	acre
NY**	382	Fencing	17373	feet
UT	382	Fencing	25203	feet
UT	378	Pond	4	number
NY**	362	Diversion	1580	feet

Hydrologic Unit Area Projects

Project	Practice #*	Practice Name	Adopted	Units
IN	362	Diversion	1050	feet
AL	359	Waste treatment lagoon	23	number
OR	359	Waste treatment lagoon	2	number
UT	352	Deferred grazing	2466	acre
OR	350	Sediment basin	3	number
UT	344	Crop residue use	981	acre
MI	344	Crop residue use	22418	acre
AL	344	Crop residue use	435	acre
IN	344	Crop residue use	4942	acre
IN	342	Critical area planting	49	acre
MI	342	Critical area planting	7	acre
UT	342	Critical area planting	2	acre
AL	340	Cover and green manure crop	198	acre
IN	340	Cover and green manure crop	361	acre
MI	340	Cover and green manure crop	3542	acre
NY**	340	Cover and green manure crop	3	acre
IL	340	Cover and green manure crop	22489	acre
AL	330	Contour farming	428	acre
UT	329	Conservation tillage	678	acre
MI	329	Conservation tillage	20795	acre
IL	329	Conservation tillage	52248	acre
AL	329	Conservation tillage	297	acre
IN	329	Conservation tillage	28464	acre
IL	328	Conservation cropping sequence	51636	acre
IN	328	Conservation cropping sequence	12519	acre
AL	328	Conservation cropping sequence	335	acre
OR	328	Conservation cropping sequence	13432	acre
UT	328	Conservation cropping sequence	1256	acre
MI	328	Conservation cropping sequence	22328	acre
NY**	328	Conservation cropping sequence	244	acre
IL	327	Conservation cover	3746	acre
UT	327	Conservation cover	180	acre
IN	327	Conservation cover	5306	acre
UT	326	Clearing & snagging	1500	feet
UT	324	Chiseling & subsoiling	84	acre
UT	322	Channel vegetation	13	acre
DE	317	Composter	36	number
UT	314	Brush management	1639	acre
UT	314	Brush management	1639	acre

Hydrologic Unit Area Projects

Project	Practice #*	Practice Name	Adopted	Units
OR	313	Waste storage structure	4	number
UT	313	Waste storage structure	12	number
DE	313	Waste storage structure	60	number
AL	313	Waste storage structure	60	number
MI	313	Waste storage structure	1	number
OR	312	Waste management system	10	number
DE	312	Waste management system	65	number
NY**	312	Waste management system	1	number
IN		Waste storage/treatment	19	number
IN		Integrated crop management	1805	acre
IL		Soil moisture monitoring	10	sites
IL		Record keeping	1272	acre
NY**		Record keeping	437	acre
IL		Well sealing	1	number
IL		Well testing	4	number
NY**		Manure analysis	11	number
DE		Manure analysis	203	number
DE		Manure spreader calibration	70	number
NY**		Manure spreader calibration	5	number
OR		Sprinkler irrigation	4870	acre
IL		Irrigation scheduling	948	acre
OR		Irrigation scheduling	4960	acre
OR		Bubbler	64	number
OR		Surge irrigation	60	acre
OR		Banding of nutrients	1100	acre
NY**		Split application of N	80	acre
OR		Split application of N	5951	acre
NY**		Nutrient credit for crops	100	acre
OR		Fertilizer application and timing	10711	acre
IL		Soil testing	2417	acre
DE		Soil testing	3620	number
NY**		Soil testing	570	acre
OR		Soil testing	11901	acre
IL		Irrigation system, sprinkler	44708	acre
IL		Irr water conveyance-steel pipeline	411	feet

* NRCS practice #s are given to reference established practices for which national standards and specifications exist. Practices without NRCS numbers are innovative or regional practices for which national standards have not yet been established or are components of national practices.

**= FY 1993 Data only

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ACRONYMS

Agencies and Programs:

ARS - USDA Agricultural Research Service

ASCS - USDA Agricultural Stabilization and Conservation Service

CES - Cooperative Extension System

FSA - USDA Farm Services Agency

CSREES - USDA Cooperative State Research, Education, and Extension Service

EPA - U.S. Environmental Protection Agency

ES - USDA Extension Service

ET&FA - Education, Technical, and Financial Assistance Committee of the USDA Working Group on Water Quality

NRCS - USDA Natural Resources Conservation Service

SCS - USDA Soil Conservation Service

TVA - Tennessee Valley Authority

USGS - U.S. Geological Survey

Other Acronyms:

ADSWQ - Automated Data System Water Quality

AGNPS - Agricultural NonPoint Source model

BOD - Biochemical Oxygen Demand

COD - Chemical Oxygen Demand

CAMPS - Computer Assisted Management and Planning System

CREAMS - Chemicals, Runoff, and Erosion from Agricultural Management Systems model

DP - ET&FA Demonstration Project

EPIC - Erosion-Productivity Impact Calculator model

FOCS - Field Office Computing System

GIS - Geographic Information System

GLEAMS - Groundwater Loading Effects of Agricultural Management Systems model

GRASS - Geographic Resources Analysis Support System

HUA - ET&FA Hydrologic Unit Area project

ICM - Integrated Crop Management

IPM - Integrated Pest Management

LTA - Conservation practice Long-Term Agreement

MCL - Maximum Contaminant Level

MSEA - Management Systems Evaluation Area

NLEAP - Nitrogen Leaching and Economic Analysis Package model

NPURG - National Pesticides/Soils Database and User Decision Support System for Risk Assessment of Ground and Surface Water Contamination model

SPISP - Soil-Pesticide Interactions Screening Procedure

SWAT - Soil and Water Assessment Tool

SWRRBWQ - Simulator for Water Resources in Rural Basins-Water Quality model

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